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BULLETIN No. 33.

U. S. DEPARTMENT OF AGRICULTURE.
OFFICE OF EXPERIMENT STATIONS.

THE
COTTON PLANT:

ITS HISTORY, BOTANY, CHEMISTRY, CULTURE,
ENEMIES, AND USES.

PREPARED UNDER THE SUPERVISION OF A. C. TRUE, PH. D.,
DIRECTOR OF THE OFFICE OF EXPERIMENT STATIONS.

WITH AN INTRODUCTION BY

CHARLES W. DABNEY, Jr., Ph. D.,
ASSISTANT SECRETARY OF AGRICULTURE.



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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., June 15, 1896.

SIR: I have the honor to transmit herewith a bulletin on the cotton plant, which includes summaries of information on different topics relating to this plant considered in their agricultural bearings. The effort has been made to present such facts as would be useful to the students of our agriculture, to the investigators at the experiment stations, and to that increasing body of intelligent agriculturists who are interested in thoroughly acquainting themselves with the past and present condition of our agricultural industries, with a view to discovering means for their improvement. No attempt has been made to discuss the problems of cotton manufacture, the purpose being to confine the bulletin strictly within agricultural lines.

The introduction to the bulletin has been written by C. W. Dabney, jr., Ph. D., Assistant Secretary of Agriculture, whose lifelong acquaintance with the practical problems of Southern agriculture has been supplemented by special studies of scientific questions relating to the crops of that region, particularly in connection with his duties as director of the North Carolina and Tennessee agricultural experiment stations.

The chapter on the history and general statistics of cotton as an agricultural plant has been prepared by Mr. R. B. Handy, of this office, who has, as far as practicable, examined the original sources of information and carefully collated the literature of this subject. Many details of the earlier history of cotton are obscure, and their interpretation will always remain largely a matter of individual opinion. The article herewith is, however, a careful and independent review of the evidence available, and the numerous references to the authorities will enable the student to examine the matter for himself should he care to pursue it further.

The chapter on the botany of cotton, by Walter H. Evans, Ph. D., of this office, has involved a very considerable amount of research, the results of which have been very largely of a negative character. An examination of the widely scattered literature of the histology and physiology of agricultural plants has revealed surprisingly few investigations on the cotton plant. The systematic botany of this plant is also in a very

unsatisfactory state, and it is quite difficult to make definite statements which will not be subject to more or less serious criticism. For the purpose of this bulletin it was deemed best to make a concise and orderly statement of the facts as they appeared to the author after a careful review of available literature without entering into discussion of disputed points.

The chapter on the chemistry of cotton, by Mr. J. B. McBryde, chemist of the Tennessee Agricultural Experiment Station, and Mr. W. H. Beal, of this office, includes summarized statements of the results of chemical investigations of the cotton plant and detailed tables of analyses, together with a bibliography of the subject.

In the chapter on climatology and soils, by Prof. Milton Whitney, chief of the Division of Soils of this Department, general considerations relating to the climate and soils of the cotton belt of this country have been briefly stated, the results of soil investigations as they affect the problems of cotton culture have been explained, and some typical soils of different cotton regions have been concisely described. A short compilation of the results of chemical analyses of soils in the cotton States, selected from the large number of analyses given by Prof. E. W. Hilgard in the Tenth Census of the United States, has been added, with a view to indicating in a general way what chemical analysis has shown regarding the soils of this region.

The chapter on the manuring of cotton, by H. C. White, Ph. D., president and professor of chemistry of the Georgia State College of Agriculture and Mechanic Arts and vice-director and chemist of the Georgia Agricultural Experiment Station, contains a brief history of the use of fertilizers for cotton and a summary of the results of experience and experiment in manuring this crop.

The chapter on cultivated varieties of cotton, by S. M. Tracy, M. S., director and botanist of the Mississippi Agricultural Experiment Station, includes brief descriptions of the principal varieties cultivated in the United States, with a discussion of the ways of determining their relative importance and of the methods used in the origination and improvement of varieties.

The chapter on the culture of cotton was prepared by Mr. Harry Hammond, of South Carolina, author of the article on Cotton Production in South Carolina in the Tenth Census, and a cotton planter of long experience. For the purposes of this article the cotton belt has been divided into a number of regions characterized by more or less uniform conditions of soil and climate, and the general conditions of cotton culture in each region have been concisely described. The general results of experience in the management of this crop are also stated and the cost of production together with other economic factors affecting the great industry of cotton raising have been briefly considered. It is believed that this article will afford the reader a comprehensive view of the present status of cotton culture in this country.

A brief summary is appended of the relatively few experiments on cotton culture thus far reported by the agricultural experiment stations, prepared by Mr. J. F. Duggar during his connection with this office.

The chapter on diseases of cotton was prepared by George F. Atkinson, M. S., professor of botany in Cornell University, who, during his connection with the Alabama Agricultural Experiment Station, conducted the most extensive investigation of these diseases thus far attempted. The summarized statements contained in this article are intended for the general reader rather than the specialist.

The chapter on insects which affect the cotton plant in the United States, by L. O. Howard, Ph. D., Entomologist of this Department, includes a summary of the principal results of the extended investigations of the Division of Entomology and of the United States Entomological Commission, intended for the use of the general reader. Of special interest is the account of the investigations on the Mexican cotton-boll weevil, recently conducted under Professor Howard's supervision.

The chapter on the handling and uses of cotton, by Mr. Harry Hammond, treats of the storage, ginning, and baling of cotton, the manufacture and uses of cotton-seed meal and oil and other by-products, and the marketing of the lint. Only such information is given in this article as was deemed to belong to the agricultural side of the questions relating to the handling and use of the cotton crop.

The chapter on the feeding value of cotton-seed products, by Mr. B. W. Kilgore, assistant chemist of the North Carolina Agricultural Experiment Station, is a summary of the results of the investigations on this subject carried on at the agricultural experiment stations and kindred institutions in this country and abroad.

Throughout the bulletin careful and somewhat complete references to the sources of information have been made in footnotes, and a list of works which are not thus referred to, but which may be of interest to students of the cotton plant, is given at the end of the bulletin.

The labor involved in the final arrangement of material and the preparation of the bulletin for the press has largely devolved on Mr. W. H. Beal, of this office, and a large amount of work in the collection of literature and in the working up of details has also been performed by Mr. R. B. Handy, of this office.

The preparation of this somewhat comprehensive bulletin on the cotton plant has involved a very large amount of labor in the collation of materials, in the selection and arrangement of the information to be given under each head, and in the securing of accuracy and reasonable uniformity in details. On many topics long search has revealed a surprising paucity of reliable information. It is evident that thus far very few careful investigations of the cotton plant have been made. A great field of research remains open to our agricultural experiment stations, on which they have hardly begun to enter. When we consider how vast are the interests involved in the cotton industry, we

realize the total inadequacy of the efforts thus far put forth to solve the perplexing problems confronting the cotton planter. This bulletin will have served an important purpose if it calls attention to the need of more thorough investigation of these problems and stimulates useful inquiries in this direction. The conditions under which the workers in our experiment stations are laboring largely prevent their making comprehensive surveys of the work already done in various lines before attempting further investigations. They are compelled too often to attack the problem which seems most immediately pressing without such preliminary study of its relations to other problems as would make their work most effective and success most probable. This bulletin has been prepared primarily to relieve this difficulty as regards the cotton plant.

The conditions of our agriculture have hitherto induced superficial methods of culture and handling of our staple crops. The need of greater attention to finer distinctions and nicer economies is beginning to be at least dimly discerned by the masses of our agricultural population. As the real situation becomes clearer there will undoubtedly be an increasing demand for such information regarding these crops as can be obtained only as the result of elaborate and far-reaching investigations at our agricultural experiment stations. It is our present duty to pave the way for the successful conduct of such investigations by reviewing the past and carefully noting the conditions of the present, and to supply the materials out of which the master workmen of the future may construct lasting structures of practical truth. The articles herewith are submitted as a contribution to this end, and their publication as Bulletin No. 33 of this office is respectfully recommended.

Respectfully,

A. C. TRUE,
Director.

HON. J. STERLING MORTON,
Secretary of Agriculture.

THE COTTON PLANT.

INTRODUCTION.

By CHAS. W. DABNEY, JR., PH. D.,
Assistant Secretary of Agriculture.

Cotton is the principal product of eight great States of this Union, and the most valuable "money crop" of the entire country. Climatic conditions practically restrict its cultivation to a group of States constituting less than one-fourth of the total area of our country, and yet the value of the annual crop is exceeded among cultivated products only by corn, which is grown in every state of the Union, and occasionally—four years out of the last ten—by wheat. Cotton furnishes the raw material for one of our most important manufacturing industries and from one-fourth to one-third of our total exports.

Considered without reference to any particular country, its economic importance is far beyond numerical expression; for while the total crop of the world is approximately ascertainable, the effect of cotton upon the commercial and social relations of mankind is too far-reaching for estimation. Of the four great staples that provide man with clothing—cotton, silk, wool, and flax—cotton, by reason of its cheapness and its many excellencies, is rapidly superseding its several rivals. Fifty years ago only about 2,500,000 bales of cotton, or less than the present production of Texas, were annually converted into clothing; the spindles of the world now use over 13,000,000 bales per annum. Yet less than half the people of the world are supplied with cotton goods made by modern machinery, and Edward Atkinson has estimated that it would require annually a crop of 42,000,000 bales of 500 pounds each to raise the world's standard of consumption to that of the principal nations.

Cotton stands preeminent among farm crops in the ease and cheapness of its production, as compared with the variety and value of its products. No crop makes so slight a drain upon the fertility of the soil, and for none has modern enterprise found so many uses for its several parts. The cotton plant yields, in fact, a double crop—a most beautiful fiber and a seed yielding both oil and feed, which, although neglected for a long time, is now esteemed worth one-sixth as much as the fiber. In addition to this, the stems can be made to yield a fiber which waits only for a machine to work it, and the roots yield a drug. It is entirely possible, therefore, that cotton may ultimately be grown as much for these parts as for the lint.

The history of cotton production in the United States differs from that of almost every other agricultural product in several important

particulars. For nearly three-quarters of a century slave labor was almost exclusively employed in this branch of agricultural industry, and an immense majority of the colored people of to-day look to it for their chief support. Cotton was also the great pioneer crop in the new southwestern States. Not only has the westward movement of the industry been more rapid than that of any other crop, but the center of production has always been farther in advance of the center of population. As long ago as 1839 Mississippi was producing almost one-fourth of the entire crop of the country. Recent years have witnessed an enormous development in the regions to the west, which would have carried the center of production across the Mississippi River if the cultivation of cotton, unlike that of wheat and corn and other products, had not taken a new lease of life in the older States along the Atlantic seaboard, where the use of manures has both extended the area and increased the production.

Probably no equally great industry was ever more completely paralyzed or had its future placed in greater jeopardy than cotton growing in the United States during the war of 1861-1865. So great was the decrease in production which followed the effectual closing of the ports that only 1 bale of cotton was grown in 1864-65 for every 15 bales raised in 1861-62. The chief menace to the future of cotton production lay in the efforts that were put forth by other cotton-growing countries at this time to produce those particular varieties which had for so long given the United States the monopoly of the European markets; and nothing could more completely demonstrate the remarkable adaptation of our southern States to the growing of varieties which the experience of generations has proved to be the best for manufacturing purposes than the fact that it took them only thirteen years from the end of the war to regain the primacy of position which they held at its commencement.

The fact that only a very small fraction of the annual crop fails to reach a market in its raw state explains why we have a more continuous and authentic history of the cultivation of cotton in the United States than of any other important product. The ordinary fluctuations to which cotton growing in the United States is subject have been well exemplified in the last ten years, as shown by the following tables:

Year.	Production (net weight).	Area.	Total value of crop.	Exports (net weight).	Value of exports.
	<i>Pounds.</i>	<i>Acres.</i>	<i>Dollars.</i>	<i>Pounds.</i>	<i>Dollars.</i>
1886-87	3,018,360,368	18,454,603	309,381,938	2,047,308,445	206,222,057
1887-88	3,290,871,011	18,641,067	337,972,453	2,150,775,786	223,016,760
1888-89	3,309,564,330	19,058,591	354,454,340	2,275,252,020	237,775,270
1889-90	3,494,811,916	20,171,896	402,951,814	2,394,975,501	250,968,792
1890-91	4,092,678,381	20,809,053	369,568,858	2,759,049,246	290,712,898
1891-92	4,273,734,267	20,714,937	326,513,298	2,786,637,403	258,461,241
1892-93	3,182,673,375	18,067,924	262,252,286	2,104,829,500	188,771,445
1893-94	3,578,613,258	19,525,000	274,479,637	2,547,624,248	210,869,289
1894-95	4,586,594,540	23,687,950	287,120,818	3,316,406,482	204,900,990
1895-96	3,190,417,839	20,184,368	260,338,096	2,222,707,905	150,056,460
Total	36,018,319,285	¹ 19,931,539	3,185,033,538	24,605,566,536	2,261,755,202

¹Average.

Year.	Average production per acre.	Average value per pound.	Average value per acre.	Per cent of crop ex- ported. ¹	Per cent of crop retained. ¹
	<i>Pounds.</i>	<i>Cents.</i>	<i>Dollars.</i>		
1886-87	163.56	10.25	16.76	67.80	32.20
1887-88	176.54	10.27	18.13	65.36	34.64
1888-89	173.65	10.71	18.60	68.75	31.25
1889-90	173.25	11.53	19.98	68.53	31.47
1890-91	196.68	9.03	17.76	67.41	32.59
1891-92	206.31	7.64	15.76	65.20	34.80
1892-93	176.15	8.24	14.51	66.13	33.87
1893-94	183.28	7.67	14.06	71.19	28.81
1894-95	193.63	6.26	12.12	72.31	27.69
1895-96	158.06	8.16	12.90	69.67	30.33
Average.....	180.71	8.84	15.98	68.31	31.69

¹ Net weight.

These tables present some very striking contrasts. The crop of 1894-95 is shown to have been more than half as large again as that of 1886-87, while in respect to value the crop of 1889-90 was just as much in excess of that of 1892-93 or that of 1895-96. While the area cultivated fell nearly 1,900,000 acres below, and rose more than 3,700,000 acres above, the average for the entire period, the wide variation in the average yield per acre played an almost equally important part in determining the total amount of the crop. Yet it is an interesting fact that the fluctuation in yield per acre, taking the country as a whole, is less in the case of cotton than in that of almost any other product of the soil. This is attributable to the greater uniformity of the climatic conditions obtaining in the cotton belt as compared with those of other sections. The rainfall is more constant in the South than in many other sections, the changes of temperature from day to day are considerably less than at points in more northern latitudes, and the monthly means of temperatures in the growing season do not vary more than 2° or 3° in the chief cotton-growing districts. In fact, except on the Pacific Coast, there is no portion of the United States where the variability of the temperature is so small, particularly in summer, as in the Southern States and on the Gulf Coast. The increase of sunshine and heat during the months of August and September, concurrently with the decrease of rainfall, which characterize this section so distinctly, are the conditions which favor most the development of the cotton bolls. The same climatic conditions render this section of our country a most favored one for a widely diversified agriculture.

The average yield per acre during the ten years covered by the table was 180.71 pounds. Although this may be slightly above the normal yield of the American cotton crop considered as a whole, it can not be doubted that improved methods of cultivation and the increased use of manures are gradually increasing the productiveness of the cotton field, and that the time is not far distant when an average of 200 pounds per acre for the entire cotton belt will no longer excite surprise, while the yield of a bale of 500 pounds will be the standard of the best cotton planters.

One of the most important facts shown above is that over two-thirds of our entire production of cotton is, and always has been, exported. The time was, indeed, when the proportion shipped abroad was as much as 80 per cent, but the increased production in other countries and the growth of the cotton manufacturing industry in our own have reduced the proportion exported to a little under 70 per cent.

One of the serious results of an era of low prices such as that through which the country has been passing is that if it does not, indeed, entirely disable the farmer, it indisposes him to keep up the fertility of his farm. But it is when profits are small that the good results accruing from the adoption of improved methods of cultivation are most apparent. In this connection and at this time, the value to the planter of the work being done by the various experiment stations and the Department of Agriculture will be thoroughly appreciated. By using, in the most economical form, the fertilizing materials of which the soil is really in need; by disposing the surface of the field and by growing crops in proper rotation to prevent the excessive leaching and washing of the soil; by the selection of seed from plants exhibiting the most desirable qualities; by using the most efficient and economical implements and machines for working the soil; by the prompt adoption of the most approved methods of preventing the ravages of injurious insects or the spread of plant diseases, the ordinary farmer may increase his crop out of all proportion to the additional expenditure bestowed upon it. By using improved gins, adapted to the quality of the cotton grown and the uses to which it is to be put in manufacturing; by packing and handling the cotton in the best manner, and by saving and utilizing the seed or its several products in the most scientific manner, he may get a profit from his crop largely in excess of that ordinarily realized. The demand is not so much for an increased production, except relatively to the area under cultivation, as for a specialization of cotton culture and improvements in the methods of ginning and handling the product, so that the most esteemed varieties may be grown in sufficient quantity and at a price that will give the farmer a higher percentage of profit.

Wonderful results have been accomplished in the crossing, variation, and general improvement of fruits, flowers, and vegetables, but the great staples, like cotton and wheat, have been comparatively neglected in these respects. Our common cultivated species of cotton have already been transformed by peculiarities of soil and climate, by special methods of culture, and by the use of fertilizers from a perennial to practically an annual form, and by shortening the period of its growth the limits of successful cotton culture have been greatly extended. But much remains to be done in improving the varieties of cotton. No plant, however, is more susceptible to such variation and improvement than cotton, and with hundreds of intelligent planters supplementing the work of the experiment stations, results that will be of the greatest benefit to the industry can hardly fail to accrue.

HISTORY AND GENERAL STATISTICS OF COTTON.

By R. B. HANDY,
Office of Experiment Stations.

ANCIENT HISTORY.

The dawn of history shows man using various fibers for the manufacture of cloth, and the most ancient traditions of the race prove that the discovery of the art of weaving was made many centuries prior to that time.

Wool was the principal material used in Palestine, Syria, Greece, Italy, and Spain; hemp in the northern part of Europe; flax in Egypt; silk in China, and cotton in India; the inhabitants of each of these countries being well skilled in the conversion of these raw fibers into the cloth best suited to their needs.

The date at which cotton fiber was first applied to the weaving of cloth by the Hindoos is unknown, but in the digest of ancient laws ascribed to Manu, 800 B. C., cotton is referred to so often and in such a way as to indicate that it must have been known to them for generations, both as a plant and as a textile.

The following sentence is quoted from these laws as evidence of the high esteem in which the fiber was held: "The sacrificial thread of the Brahman must be made of cotton (*karpasi*), so as to be put over the head in three strings; that of the *Cshatriya* of *sana* thread, that of the *Vaisya* of woolen thread."¹

The following quotation from the same source also bears testimony to the antiquity of weaving and sizing among these people: "Let a weaver who has received 10 palas of cotton thread give it back increased to 11 by the rice water and the like used in weaving; he who does otherwise shall pay a fine of 12 panas."²

Theft of cotton thread was made punishable by fines of three times the value of the article stolen.³

Herodotus says: "There are trees which grow wild there [India] the fruit of which is a wool exceeding in beauty and goodness that of sheep. The Indians make their clothes of this tree wool."⁴

His expression "*ἀπὸ ξύλων ποιημένα*,"⁵ referring to the clothing of Xerxes's army, is more correctly interpreted "cotton fiber" than the

¹ Manu, Book II, No. 44.

² Manu, Book VIII, No. 236.

³ Manu, Book VIII, No. 397.

⁴ Herod., III, 106.

⁵ Herod., VII, 65.

fiber of trees (bast fiber). Moreover, the “ξύλινὰ ἱμάτια” of the Indians, which is the expression used by Ctesias,¹ the contemporary of Herodotus, may be considered as referring to cotton; for Varro, as reported by Servius,² states: “Ctesias says there are trees in India which bear wool.” Theophrastus says: “The trees from which the Indians make cloth have a leaf like that of the black mulberry, but the whole plant resembles the dog rose. They set them in plains arranged in rows so as to look like vines at a distance.”³

Strabo, who was most careful and accurate in both his investigations and statements, mentions the trees of India on which wool grew, and says: “The Indians use white raiment and fine white cloths and carpasa.”⁴ The last word is a form of the Sanskrit *karpasa*, Hebrew *karpas*, Latin *carbasus*, and indicates a cloth made of either cotton or flax, Brandes⁵ and Ritter⁶ maintaining that it was used by classical writers to denote cotton.

Aristobulus, contemporary of Alexander the Great, mentioned the cotton plant under the name of the wool-bearing tree, and stated that the capsule contained seed which were taken out, and that the fiber remaining was combed like wool.⁷

Nearchus, the admiral of Alexander, who conducted a part of his army down the Indus, around the shore of the Arabian and Persian gulfs to the Tigris, about 327 B. C., says: “There are in India trees bearing, as it were, bunches of wool. The natives made linen garments of it, wearing a shirt which reached to the middle of the leg, a sheet folded about the shoulders, and a turban rolled round the head, and that the linen made by them from this substance was fine, and whiter than any other.”⁸ The Greeks on this expedition made use of an inferior kind of raw cotton to pad their clothing and stuff their saddles.⁹

Pliny¹⁰ writes of the cotton plant in India with leaves similar to the mulberry and resembling the dog rose, which was sowed in the field, and from which the inhabitants made linen clothes. Here Pliny uses the word *lineas*, but the context shows that he referred to cotton. Quintus Curtius says of the Indians: “They covered their bodies from head to foot with *carbasus*; they bind shoes about their feet, linen cloths about their heads;” and, speaking of the dress of the king, he says: “The *carbasa* which he wore were spotted with purple and gold.”¹¹

¹Fragment of Ctesias (ed. Muller, p. 84).

²Comm. in Virgillii Æn., I, 649.

³Theoph. Hist. Plant., IV, 4 (p. 132, ed. Schneider).

⁴Strabo, XV, 719.

⁵Ueber die antiken Namen und die geog. Verbreit. der Baumwolle im Alterthum, p. 107.

⁶Geog. Vol. IV, 1, p. 436.

⁷Strabo, XV, 1 (Vol. VI, p. 43, ed. Siebenkees).

⁸Arrian. Ind., ch. 16.

⁹Strabo, XV, 693.

¹⁰Plin. Hist. Nat., XII, 13.

¹¹Luc., VIII, 9.

Lucan,¹ the poet, who lived in the first century of the Christian era, describes the inhabitants of India as those:

Who drink sparkling juices from tender cane,
With dyes of crocus stain their hair, and fix
With colored gems the flowing *carbasus*.

The Periplus² states that two kinds of cotton goods—a fine and a coarse grade—were sent from Ariaca and Barygaza (the modern Baroach on the Nerbudda) to Malao, Mundi, Mosyllou, Tabae, to Opone on the east coast of Africa, and to the islands lying off that coast. And the following places are mentioned in the same book³ as manufacturing centers for the same cloth: Palasimunda, Masalia (the modern Masulipatam, on the east coast of India), and the country around the mouth of the Ganges.

These references demonstrate that cotton was not only known and used by the Hindoos in early times, but that they manufactured cloth from the fiber in sufficient quantities to supply their own needs and to export, or rather sell to traders, who carried it to other places.

The cultivation of the plant or the manufacture of the cloth from the fiber did not receive as much attention in any country as in India. In fact, from 1500 B. C. until an equal number of years after the beginning of the Christian era, India was the center of the cotton industry. The cotton cloth which the Indians produced from a short fiber with primitive distaffs and rude looms was not equaled until the last half century. Some of their muslins possessed wonderful delicacy of texture.

Two Arabian travelers of the middle ages, writing of India, say: "In this country they make garments of such extraordinary perfection that nowhere else are the like to be seen. These garments are for the most part round, and woven to that degree of fineness that they may be drawn through a ring of moderate size."⁴

Marco Polo,⁵ whose work was first circulated about 1298 A. D., mentions the coast of Coromandel as producing "the finest and most beautiful cottons that are to be found in any part of the world."

Odoardo Barbosa,⁶ one of the Portuguese who visited India immediately after the discovery of the passage around Good Hope, speaks of "the great quantities of cotton cloths admirably painted, also some white and some striped, held in highest estimation," which were made in Bengal; and Cæsar Frederick⁷ mentions cotton cloth so valuable "that a small bale of it will cost 1,000 or 2,000 duckets."

¹ Luc., III, 239.

² Periplus maris Erythræi, §§ 8, 9, 10, 12, 13, 14, 31.

³ *Loc. cit.*, §§ 51, 61, 63.

⁴ *Anciennes Relations des Indes et de la Chine*, etc., p. 21.

⁵ *Travels of Marco Polo*, Book III, ch. 21, 28.

⁶ *Ramusio's Raccolta delle Navigazioni et Viaggi*, Tome I, p. 315.

⁷ *Hakluyt's Voyages*, Vol. II, p. 366, ed. 1809

Tavernier¹ says "some calicuts are made so fine you can hardly feel them in your hand, and the thread when spun is scarce discernible;" also, that "the rich have turbans of so fine a cloth that thirty ells of it put into one turban make it weigh less than four ounces." "When the muslin is laid on the grass to bleach and the dew has fallen upon it, it is no longer discernible," says Ward;² and an English review³ of the trade of the latter part of the seventeenth century designated the same fabrics as but "the shadow of a commodity." Surely the poetic writers of the Orient were justified in calling them "webs of woven wind."

Cotton was introduced into China and Japan from India, but common use of the fiber in these oriental countries, where at the present time it is even more widely used than in the West, came as slowly as the adoption of it as clothing among Europeans, and met with equally active opposition. Although China carried on an exchange of products with India in very early times, both by way of caravans and by junks coasting along the shores, it was as late as the thirteenth century of the present era before her inhabitants began the cultivation of cotton as anything but a garden plant. Marco Polo,⁴ although several years a resident of China, with every facility for observation, gives no account of cotton culture except in the province of Fo-Kien, but speaks of silk as the usual dress of the people. It appears, however, from Chinese history that the plant had been known for many centuries, but that its manufactured product was a rarity.

The introduction of cotton into China dates practically from the conquest of China by the Tartars, and it was not until 1300 A. D. or thereabouts that it was cultivated for general use.

The cotton plant also thrived in ancient times in the island of Tylos, situated near the Arabian coast in the Gulf of Persia. Theophrastus⁵ mentions wool-bearing trees which grew abundantly in this island, and which had leaves like those of the vine, but smaller. They bore a capsule about the size of a quince, which, when ripe, burst, disclosing the seed surrounded with a wool, which was woven by the people into cloth of different qualities. Pliny⁶ makes similar statements regarding the wool-bearing trees of this island.

The climate and soil of the island of Tylos were so favorable to the plant that cloth made of the cotton of Tylos was preferred to that of India.⁷ Although there is no mention of cloth being made in Tylos, it probably was made there, and also on the neighboring mainland.

¹Tavernier's Travels (Harris's Collection of Voyages, Vol. I, p. 811).

²View of the History, Literature, and Mythology of the Hindoos, Vol. III, p. 127, 3d ed.

³The Naked Truth, p. 11.

⁴Travels, Book II, ch. 74.

⁵Theoph. Hist. Plant., IV, 7, 7.

⁶Plin. Hist. Nat., XII, 21.

⁷Plin. *loc. cit.*, XII, 22.

Because Pliny describes the Arabian tree from which the fiber was secured to make a cloth similar to linen as having leaves like the palm,¹ some have doubted the presence of the true cotton plant in Arabia. But Theophrastus² says Arabia is a producer of the same plant, which he had just described as a product of Tylos; and Pliny, in another connection,³ describing the different kinds of cotton plants, intimates that besides the variety with the palm-like leaves, another, probably the same plant described by Theophrastus, also grew there. The Periplus⁴ mentions Omana, in the southern part of Arabia, as a place from which cotton cloth was shipped, not only to other portions of Arabia, but even to India.

The cotton plant was known on the eastern coast of Africa as well as in the southern parts of Asia. Although much has been written to prove that the ancient Egyptians used only flax for weaving and knew nothing of the cotton plant, it seems most probable that this opinion is based mainly upon a too narrow interpretation of the terms used by classical authors and the idea that both flax and cotton were never used by the same people. The fact is that both flax and cotton were used, alone and mixed, by both the Egyptians and Indians.

Egypt was one of the most ancient as well as most populous empires of antiquity, and her inhabitants were early compelled to turn their attention to other than agricultural occupations; so that the various industries were well known from the date of the earliest traditions, and among them none were more developed than weaving. While flax was probably the most common article used by Egyptian weavers in the manufacture of cloth, and linen was in fact the material of which the clothing of the people and the wrappings of their dead were usually made, it appears quite arbitrary to state that the Egyptians knew nothing of cotton, and consequently made no use of it in ancient times, for the probability is that it was through the commercial and industrial activity of this people that cotton was brought to the shores of the Mediterranean Sea.⁵

The Egyptians were adventurous sailors, and had early established a trade from ports on the Red Sea with those on the western coast of India. Doubtless they brought home many of the fine fabrics made by the skillful weavers of India from the fiber of the cotton plant. This cotton plant also grew in Egypt, for Pliny says: "In upper Egypt, toward Arabia, there grows a shrub which some call 'gossypion' and others 'xylon,' from which the stuffs are made which we call 'xylina.' It is small and bears a fruit resembling the filbert, within which is a downy wool which is spun into thread. Nothing is more to be desired than this goods for whiteness and softness. Garments are made from it which are very acceptable to the priests of Egypt."⁶ And Pollux, who

¹ Plin. Hist. Nat., XII, 22.

² Theoph. Hist. Plant., IV, 7, 8.

³ Plin. Hist. Nat., XIX, 3.

⁴ Periplus, § 36.

⁵ Brandes, *loc. cit.*, p. 111.

⁶ Plin. *loc. cit.*, XIX, 3.

lived about 150 A. D., reports that "among the Indians, and now also among the Egyptians, a sort of wool is obtained from a tree. The cloth made from this wool may be compared to linen, except that it is thicker. The tree produces a fruit most nearly resembling a walnut, but three-cleft. After the outer covering has divided and become dry the substance resembling wool is extracted and is used in the manufacturing of cloth for weft, the warp being of linen."¹

These two passages taken together are worthy of consideration, and no mere dispute as to the meaning of the terms used by other writers can throw discredit on such distinct statements. The description Pollux gives of the cotton tree is remarkably correct—more so than any given before his time, unless it be that of Aristobulus and Nearchus, the companions of Alexander the Great. The description of the pericarp as three-cleft and the comparison of the boll to a walnut are in striking agreement with the facts. Besides, he goes into details as to the use of the thread for the weft only, while use of linen thread for warp is stated.

Although Herodotus states, in referring to the Egyptian priests, that they wore linen clothes,² Pliny, as above quoted, says that cotton clothes were very acceptable to them, and Philostratus³ confirms his statement. Just here it may be well to remark that the word translated "linen" did not always refer to the fiber of which a material was made, but often to the general appearance of the cloth;⁴ therefore cloth made of either flax or cotton alone or mixed is called linen; so that the direct statements of these authors are not necessarily contradictory. Moreover, the use of cotton, a vegetable fiber, in the garment of the priests would be considered equally as pure as that of linen, because it would not be in conflict with the religious rules which proscribed wool, an animal product.

The fact that all mummy cloths, so far as yet examined, have been found to consist of flax has been used as a basis for an argument to prove that cotton was not used by the Egyptians; but it seems far from conclusive, as for religious reasons flax alone may have been used for that purpose, while cotton, wool, and silk may have been regularly used by the living for clothing or ornament. Elsewhere it is even stated that the form and manner of wearing these clothes was like a shawl or mantle,⁵ and that the Egyptian cotton cloth was thicker than that made of linen and was embroidered.⁶

In reference to the lands on the west coast of Asia, there are so many traces of the use of cotton, especially by the Semitic tribes of antiquity,

¹ Polluc. Onomast., VII, 75.

² Herod., II, 37.

³ Philostr. Vit. Apollon., II, 9.

⁴ Müller, Handbuch der klas. Alterth. Wissensch., Vol. IV, p. 925, note 2.

⁵ Clem. Alex., Paedag., II, 10; and Polluc. Onomast., VII, 72.

⁶ Polluc. Onomast., VII, 75.

that the suggestion arises that perhaps this country was a habitat of the plant, as America is known to have been.

The vegetable fiber which Josephus¹ calls *κεδων*, the Hebrew *ketonet*, modern Arabic *kutn* (a sound which appears also in Phœnician, Syrian, and Chaldee), was without doubt the product of the herbaceous cotton plant which to this day grows in the coast lands of western Asia, where in many places it is carefully cultivated.²

The country around Jericho was especially noted for this product; and Hierapolis, in Syria, was formerly known as Magog,³ which word, according to the opinion of modern scholars,⁴ would be more properly spelled Mabog (cotton town). It was also known as Bambyce, a word which clearly refers to cotton.⁵

The manufacture of cotton goods known as *othonion* is credited to Cilicia and Palestine, in Asia Minor, by very careful and painstaking authors,⁶ and Movers states that the inhabitants of that country prior to the Hebrews, 1500 B. C., made use of cotton, and mentions the trade of the Phœnicians with the rich tribes of southern Arabia, stating that they furnished them large quantities of cotton goods.⁷

Claudianus⁸ throws some light on the industries and trade of the Hebrews when he says that the bright-colored cloths which the Indians valued so highly were obtained from these people, though perhaps he erred, substituting them for their kindred, the Phœnicians, whose trade was widespread and whose manufactures were famous. It must be remembered that *othonion*⁹ was generally, although not invariably, made of cotton.

From very early time the Greeks vied with the Phœnicians and the Egyptians in artistic spinning and weaving, and as early as 1200 B. C. had reached a stage of advancement in those arts which has been surpassed only by the most skillful manufacturers during the present century. Although, as has been stated at the opening of this chapter, the material used was generally wool, linen soon became common, and cotton was introduced at a later period.

The Greeks must have known of cotton and some kind of cloth made from it soon after the expedition of Alexander, for his invasion of India brought him and the men of his army in direct contact with a population which used it almost exclusively for clothing, bedding, curtains, housing for their war elephants, etc.

The earliest instance of the use of the oriental name for the plant in

¹ Joseph., Ant. Jud., III, 7, 2.

² Brandes, *loc. cit.*, p. 111.

³ Plin. *loc. cit.*, V, 23, 19.

⁴ Forbiger, *Alte. Geog.*, Bd. II, pp. 85, 643.

⁵ Brandes, *loc. cit.*, p. 103.

⁶ Clem. Alex., *Paedag.*, II, 10.

⁷ Movers, *Phönik.*, Bd. II, 3, p. 259.

⁸ Eutrop., I, 357.

⁹ Müller, *loc. cit.*, Vol. IV, p. 925, note 4.

any classical author is the line of Statius Cæcilius, who died 169 B. C., which is quoted by Monius Marcellus¹ from the Pausinachus of Statius, and reads: "*Carbasina, molochina, Ampelina.*" As these words are Greek and the play from which the verse is taken has a Greek name, it was probably taken from an earlier Greek writer, and would indicate that the cloth *carbasina*² was known to the Greeks at least 200 B. C., although it is not necessarily true that they either used it extensively or engaged in its manufacture.

The cotton plant also grew in Elis, in Achaia,³ and the town of Patræ was the center of the manufacture of material from that fiber. Pausanius⁴ unequivocally describes byssus the plant grown there as cotton, and says that the byssus of Elis was not inferior to that of the Hebrews, and that the women of Patræ gained their living by weaving cloth and headdresses of the byssus grown in Elis.⁵

There is no record of the cotton plant being cultivated in Italy prior to the Christian era, nor in fact for many centuries later, but a knowledge of the use of its fiber, either raw, for the manufacture of cloth, or already woven for clothing, must have been widespread among the Romans prior to the opening of that era.

Elis (Achaia), Syria, Cilicia, Palestine, and Egypt were acquired by Roman arms from 150 to 30 B. C., and it has been shown above that all of these countries produced the cotton plant and their inhabitants spun and wove its fiber into a cloth, which must have attracted the attention of their Roman conquerors because of its superiority to the products of their home manufacture. Fine and tasteful cloth must have been sent from Greece, Syria, and Egypt to Rome, and, in fact, among the imported articles upon which a tax (tariff) was laid cotton is mentioned.⁶

In the list of dutiable articles given in the Digest of Justinian⁷ occur *opus byssinum*, *carbasum*, and *carbacea*. *Carbasum*, according to Brandes,⁸ is cotton cloth, *carbacea* cotton yarn, *opus byssinum* other and various articles made of cotton fiber, as the hair nets of Patræ.

Dirksen⁸ says that *opus byssinum* can only mean fine cotton cloth, i. e., Indian muslin, which, under the Roman Emperors, was much sought after for the dresses of the coquettish dames of that luxurious time; and that *carbacea* is probably *othonium*, which latter, Arrian⁹ says, was made from *carbasum* (a word derived from the Indian word

¹ Libr., XVI.

² This was imported from India. - Periplus, §§ 6, 14, 48, 57.

³ Plin. Hist. Nat., XIX, 1, 4; and Curtius Pelop., Vol. II, p. 10.

⁴ Paus., V, 5, 2; VI, 26, 4; VII, 21, 14.

⁵ Brandes, *loc. cit.*, p. 117.

⁶ Brandes, *loc. cit.*, p. 118.

⁷ Dig., XXXIX, tet. 4, 16, § 7.

⁸ H. E. Dirksen, Abhandlung der Berlin Akademie der Wissenschaft, 1843, p. 94.

⁹ Periplus mar. Erythr., § 24.

carpas), and that that product of the weaver's skill in central India was the object of an active trade with inhabitants of Rome.¹

Müller,² in describing the clothes and personal ornaments used by the Romans in the latter part of the Republic, says: "Hand in hand with the change of customs, there were many changes in their clothes in stuff, color, manner of wearing, and in cut." And, after enumerating these changes, he says: "Besides these, they use *carbasus* or *carpasus*—cotton or shirting—that is a fine, thick woven stuff, made sometimes of linen, sometimes of cotton."³

Müller also mentions cotton cloth as being used for clothing by the Romans in the period just preceding the Diocletian era, or prior to 284 A. D.

The oriental custom of using cotton as a protection from the sun was followed by the Romans, for Verres, when prætor in Sicily (70 B. C.), used tents with coverings of cotton, and P. Lentulus Spinther, in the year 63 B. C., covered the theater with cotton awnings at the Apollinarian games,⁴ to which fact Lucretius⁵ apparently refers when he compares the clouds spread over the sky to the awnings of *carbasus* which veiled the spectators from the sun's rays during the games. Although known and used by the Romans, it is probable that the material made from cotton fiber was too expensive because of the cost of transportation to compete with the home manufactures of wool or flax, and that cotton was not in general use among the people. It must also be remembered that many of the articles of clothing which at the present time are made of cotton cloth were not worn at all by the people of antiquity, and that, therefore, this material was not as well adapted to their need as to ours. Nor must it be supposed that cotton goods at any time wholly supplanted linen fabrics, even in the East. Linen was widely used not only in Egypt and the countries on the border of the Mediterranean, but also in Arabia and Persia, as is shown by the works of eastern travelers and investigators.⁶

The culture of the cotton plant and the manufacture of its fiber were spread by the Mohammedans at the periods of their conquests into every part of the continent of Africa north of the equator, and also to them must be attributed the real introduction into Europe of the cultivation and manufacture of cotton.

Abu Zacaria Ebn el Awam,⁷ who wrote in the twelfth century, gives a full account of the mode of culture proper for the cotton plant, and

¹ Ritter, Geog., Bd. IV, 1, p. 346.

² Müller, *loc. cit.*, p. 873.

³ Ibid., p. 874.

⁴ Plin. *loc. cit.*, XIX, 3, 6.

⁵ Lucretius, VI, 108.

⁶ Thevenot's Travels in Harris's Collection, Vol. II, pp. 824, 895; Burkhardt's in Arabia, pp. 183, 184; Hamilton's Remarks on Turkey and Egypt, pp. 388, 427; Buckingham's Travels in Mesopotamia, Vol. I, pp. 145, 294, 302; Vol. II, pp. 29, 37.

⁷ Libro de Agricultura (trans. by J. A. Banqueri), Vol. II, ch. 22, p. 103.

also states that the plant was cultivated in Sicily, which island had been in possession of the Saracens from the ninth to the eleventh century.

In the reign of Abderahman III, who was ruler in Cordova from 912 to 961 A. D., many of the natural products and arts of the East were introduced, and the cotton plant, sugar cane, rice, and the silkworm were naturalized in Spain. The cotton plant was chiefly cultivated at Oliva and Candia.¹ De Marles² says: "It was the Moors who brought into Spain the cultivation of rice and cotton, of the mulberry tree, and the sugar cane."

Columbus³ found cotton growing abundantly in the West Indies in 1492. He and other explorers found it equally abundant upon the mainland of the new world, and found the inhabitants of those countries using its fiber for the weaving of cloth and showing considerable skill in its manipulation.

Cortez⁴ found cotton in Mexico in 1519; he gathered it and used the wool to stuff the jackets of his soldiers to enable them to resist the arrows of the natives.

Cotton was the chief article of clothing among the Mexicans, as they had neither wool nor silk, and did not use flax,⁵ although they possessed that plant. They made large webs from cotton fiber spun into yarn, as delicate and as fine as those made in Holland at that date. Their warriors wore cuirasses of cotton covering the body from neck to waist.⁶

Cotton fabrics made into mantles, waistcoats, handkerchiefs, counterpanes, and tapestries formed part of the presents sent by Cortez to Charles V of Spain.⁷

Pizarro found cotton in Peru in 1522, and it has been discovered in the ancient tombs of that country. The writer of this paper has seen a cotton blanket taken from around a Peruvian mummy. The fibers, to which some of the seed were still clinging, were loosely spun into thick yarn and were in a good state of preservation.

Magellan⁸ saw cotton among the Brazilians, who used a thread formed of its fiber to make fishing nets, clothing, and hammocks.

In a word, everywhere between the parallels of 40° north and 40° south latitude, with the exception of the extensive region of the United States now known as the cotton belt, cotton, either in its wild or cultivated state, was known and used at the date of the settlement of America.

The history of the introduction and spread of cotton culture in the

¹ History of Mohammedan Empire in Spain, Shakespeare and Horne, p. 263.

² Histoire de la Domination des Arabes et des Maures en Espagne, etc., translated by Joseph Condé, Tome I, pp. 468, 469.

³ Ramusio's Collection, Tome II, pp. 2, 4, 16, 50.

⁴ Clavigero, Histoire Mexique, Tome VII, § 58.

⁵ Clavigero, *loc. cit.*, Tome I, § 7.

⁶ Humboldt, Researches, Vol. I, p. 202.

⁷ Clavigero, *loc. cit.*, Tome VII, §§ 57, 66.

⁸ Ramusio's Collection, Tome I, p. 353.

United States is so closely connected with the changes in the methods of manufacturing cotton cloth in Europe that it is first necessary to consider, at least briefly, the development of those inventions which created such an unprecedented revolution in the textile arts.

EARLY COTTON MANUFACTURE IN EUROPE.

As we have seen, knowledge of the cotton plant and of the use of its fiber was many centuries making its way from India to the southern borders of Europe, and it appears to have taken as many more to introduce the culture of the plant and the manufacture of cotton cloth into that country.

Neither the Romans nor their successors engaged in the cultivation of cotton or the manufacture of muslins. Descriptions of the production and manufacture of silk, linen, and wool in Sicily, Italy, France, and southern Europe generally are to be found in the writings of mediæval authors, but not of cotton. Spain at the western and Turkey at the eastern extremity of the Mediterranean Sea were the first to engage in this industry, and there it was introduced by the Mohammedan conquerors.

Baines,¹ writing of the introduction of cotton into eastern Europe, says:

I have not been able to ascertain at what time cotton began to be manufactured in Turkey in Europe; but there seems no reason to think that it was before the conquests of the Turks in Roumania, in the fourteenth century; nor could it have been much after, as the victorious settlers would naturally bring with them their own arts, and the use of cotton garments was then common in Asia Minor. The cotton plant found a congenial soil and climate in Roumania and Macedonia, where it is now (1835) cultivated to a great extent, and the spinning and weaving of the wool forms one of the most important branches of industry in that country.

A passage in *Historia Critica de España*,² though somewhat ambiguous, would imply that the manufacture of linen, silk, and cotton existed in Spain in the ninth century; and De Marles states that the cotton manufacture was introduced into Spain during the reign of Abderahman III, in the tenth century, by the Moors, who excelled in the arts of tanning and preparing leather, of weaving cotton, linen, and hemp, and in the manufacture of silk stuffs. In the fourteenth century Granada was noted for its manufacture of cotton, and Ebn Alkhatib states in a history of the country:

Here you find also the coccus with which the cotton stuffs are dyed, for there was a great abundance of cotton as well for commerce as for use in manufacture, and the cotton garments made here are said to be superior to those of Assyria in softness, delicacy, and beauty.³

The arts and civilization of Mohammedan Spain, however, did not spread rapidly into Christian Europe. Extensive as was the commerce

¹ History of the Cotton Manufacture, p. 46.

² Masdeu, *Historia Critica de España*, Vol. XIII, p. 131.

³ Casiri: *Bibliotheca Aribico-Hispana Escorialensis*, Vol. II, p. 248.

carried on by the Mohammedans, it was nearly all eastward with Africa and India. Even the Spanish Christians learned but little from the invaders of their country, with whom they waged an incessant contest for eight centuries, and the manufacture of cotton was confined to the southern borders of Europe until the sixteenth century. The historian¹ of the commerce of Barcelona says:

One of the most famous and useful of the industries of that city was the manufacture of cotton; its workers were united in a guild in the thirteenth century, and the names of two of its streets have preserved the memory of the ancient locality of their shops.

He also says the trade was known by the name of "fustian manufactures" (*fustaneros*, i. e., weavers of cotton goods), and was so ancient that in the year 1255 the exercise of the trade was confined to the extremities and suburbs of the city because of the annoyance the shops caused others in their vicinity. This name "fustian" comes from *fuste*, which means substance, and is so called because it gives substance to the thinner cloth or silk garments in which it was used as a lining.²

In the absence of dates, it is difficult to judge of the correctness of the claim that fustians were first made in Flanders, but it is possible that the Flemings may have acquired the art of the manufacture of cotton from the Turks during the Crusades, as they did many other arts. This does not invalidate the Spanish claim as to the origin of the manufacture in Barcelona, as the trade name was applied to the new Flemish stuffs.

The earliest discovered date at which cotton manufacture existed in Italy was in the beginning of the fourteenth century, at which time a historian of Venice dates its introduction to that city. Venetian fustians were among the articles enumerated as traded in by the English Society of Merchants and Adventurers in 1645.³ Among the imports to Antwerp in 1560 fustian and dimitics of many fine sorts from Milan are mentioned. Antwerp also imported, about this time, fustians, linen, tapestry, etc., and exported to England cottons and cotton wool, the latter of which the merchants of Antwerp are said to have procured from Portugal. There is also a list of foreign goods imported by the English Society of Merchants and Adventurers in 1601 from Holland and Germany in which fustian, said to have been manufactured in Nuremburg,⁴ appears.

When cotton manufacture was introduced into England is not definitely settled. There is no mention of the manufacture or use of cotton in the celebrated poor law of Elizabeth (1601), though hemp, flax, and wool are expressly named. The first authentic record is in Roberts's Treasure of

¹ Capmany, Tome I, Part III, p. 50.

² Diccionario de la Real Acad. Espana.

³ Baines, *loc. cit.*, p. 45.

⁴ A treatise of commerce, 1601, p. 23, mentioned by Baines.

Traffic, published in 1641; but it is possible, and even probable, that the art was imported from Flanders by the artisans who fled from that country to England in the latter part of the sixteenth century, as it is probable that the manufacture had established itself more or less firmly before it attracted the attention of the author of the above-named pamphlet. We may presume, then, that it was well established in England by 1641, but after that date the spread was not rapid. The crudeness of the machinery for spinning was such that fine yarn could not be made. Both spinning and weaving were done by individuals and families in their own houses on clumsy and heavy machines. These implements were but little better than those in use two thousand years before. The distaff, the earliest of spinning machines, was still in use, and the best to be had was the one-thread spinning wheel. The loom used was scarcely an improvement on that which the East Indian had used centuries before, though it was constructed with greater firmness and compactness. Owing to imperfections in their machines, it was impossible for the Europeans to make cotton yarn combining strength and firmness. The yarn when spun was loose and flimsy; to make it strong it had to be heavy.

The finished web had often to be carried a long distance to market. It was only in 1760 that Manchester merchants began to furnish the weavers in the neighboring villages with linen yarn and raw cotton and to pay a fixed price for the perfected web, thus relieving the weavers of the necessity of providing themselves with material and seeking a market for their cloth, and enabling them to prosecute their employment with greater regularity.¹

It was also about that time that England began to export her cotton goods, for until then her weavers had not been able to do more than supply the home demand. This foreign trade at once increased the demand for cotton goods, and the increased demand presented a problem which the manufacturers at first found difficult of solution. The procuring of supplies of linen yarn needed for the warp of these textiles was not difficult, but where was the cotton yarn to come from? The spinners were producing already as much as their rude machines would permit, and additional spinners were not to be had. The demand for cotton thread exceeded the supply; the price of yarn rose with the demands of trade and the extension of the manufacture and operated as a check to the further increase of the exports. The trade had reached the point where hand carders, single-thread spinning wheels, and the hand loom, requiring a man to each machine, were clearly inadequate to the service, and the cotton trade of Great Britain in the middle of the eighteenth century seemed to have reached its limit. About this time Hargreaves, Arkwright, Crompton, Cartwright, and Watt, men either directly or indirectly engaged in and familiar with the needs of the cotton manufacture, invented machines which raised

¹ Baines, *loc. cit.*, p. 115.

the trade from an experimental, or at least a struggling, industry into the most important manufacture of the world. The carding engine, the spinning jenny, the spinning frame, the stocking frame, the power loom, and the adaptation of the steam engine to the propulsion of these machines at once supplied the means of producing an immense amount of yarn and cloth. These inventions, it is true, were not in themselves perfect, but the principles on which they were built are those on which the most complicated textile machines of this day are based.

The supply of raw material to meet the demands of the trade was limited. The West Indies, the Levant, and India were the countries from which this supply was drawn, but they were unable to furnish enough raw cotton to keep the new machines in operation, and it was necessary to look elsewhere.

America was the only hope of the cotton manufacturer; but as at that time the United States produced little or no cotton, for a few years all the increased supply came from Brazil.

COTTON IN THE UNITED STATES.

As Great Britain was the last of the European countries to take up cotton manufacture, and has carried it to its fullest development, so the United States was the last to enter the list of cotton-producing countries, and has been for nearly a hundred years the foremost of them all. The powerful influence that the production of cotton has had upon the commerce, industrial development, and civil institutions of the United States can scarcely be realized by one unfamiliar with the subject.

It is doubtful whether cotton is indigenous to any part of this country, and we have no authentic record of the precise time of its introduction. Cotton seed was brought in from all quarters of the globe, and the American plant, the result of innumerable crossings, remains, as to its origin, a puzzle to botanists.

The beginning of the culture of cotton in the United States occurred about one hundred and seventy-five years before the industry became at all important. The first effort to produce cotton on the North American continent was probably made at Jamestown the year of the arrival of the colonists.¹ In a pamphlet entitled *Nova Britannica; Offering Most Excellent Fruits of Planting in Virginia*, published in London in 1609, it is stated that cotton would grow as well in that province as in Italy. In another pamphlet, called *A Declaration of the State of Virginia*, published in London in 1620, the author mentions cotton, wool, and sugar cane among the "naturall commodities dispersed up and downe the divers parts of the world, * * * all of which may also be had in abundance in Virginia."

¹Description of the New Discovered Country, British State Papers, Colonial, Vol. I, 15, I; Economic History of Virginia in the Seventeenth Century, Bruce, Vol. I, p. 194.

According to Bancroft,¹ the first experiment in cotton culture in the colonies was made in Virginia during Wyatt's administration of the government. Writing of that period, he says:

The first culture of cotton in the United States deserves commemoration. In this year (1621) the seeds were planted as an experiment, and their "plentiful coming up" was at that early day a subject of interest in America and England.

Cotton wool was listed in that year at 8d. a pound, which shows that it may have been grown earlier, for it is scarcely possible that it could have been grown, cleaned, and received in market in the same year.

Seabrook² states that the green-seed, or upland, variety was certainly grown in Virginia to a limited extent at least one hundred and thirty years before the Revolution. Some of the early governors of that colony were especially energetic in their efforts to encourage its cultivation. Among these were Sir William Berkeley, Francis Morrison, his deputy, and Sir Edmund Andros. The latter, says one authority,³ "gave particular marks of his favor toward the propagation of cotton, which since his time has been much neglected."

The exports of the Virginia colony during the first thirty years of its existence were confined almost exclusively to tobacco, but there is evidence that in the latter half of the seventeenth century cotton was cultivated and manufactured among the planters for domestic consumption. Burk⁴ states that "after the Restoration [1660] their attention was strongly attracted to home manufactures as well by the necessities of their position as by the encouragement of the assembly and the bounty offered by the King. But the zeal displayed in the outset for these products gradually cooled, and if we except the manufacture of coarse cloths and unpainted cotton, * * * nothing remained of the sounding list prepared with so much labor by the King and recommended by legislation, premium, and royal bounty."

Among the earliest historical references to cotton in this country is that contained in "A brief description of the Province of Carolina, on the coasts of Florida, and more particularly of a new plantation begun by the English at Cape Feare, on that river, now by them called Georges River," published in London in 1666. The author of this tract, whose name is not given, says: "In the midst of this fertile province, in the latitude of 34°, there is a colony of English seated, who landed there the 29th of May, A. D. 1664." After giving an account of the fertility of the soil and its natural products, he adds: "But they have brought with them most sorts of seeds and roots of the Barbados, which thrive in this most temperate clime. * * * They have indigo, very good tobacco, and cotton wool." Robert Horne mentions cotton among the products of South Carolina in 1666. In Samuel Wilson's Account of the

¹ History of the United States, Vol. I, p. 179.

² Origin, Cultivation, and Uses of Cotton.

³ Beverly's History of Virginia, p. 90.

⁴ History of Virginia, Appendix to Vol. II.

Province of Carolina in America, addressed to the Earl of Craven, and published in London in 1682, it is stated that "cotton of the Cyprus and Smyrna sort grows well, and good plenty of the seed is sent thither," and among the instructions given by the proprietors of South Carolina to Mr. West, the first governor, is the following: "You are then to furnish yourself with cotton seed, indigo, and ginger roots." He was also instructed to receive the products of the country in payment of rents at certain fixed valuations, among which cotton was priced at 3½d. per pound.

In 1697, in a memoir addressed to Count de Pontchartrain on the importance of establishing a colony in Louisiana, the author,¹ after describing the natural productions in the country, says: "Such are some of the advantages which may be reasonably expected, without counting those resulting from every day's experience. We might, for example, try the experiment of cultivating long-staple cotton." The presumption is that the short-staple variety had already been tried.

In the very beginning of the eighteenth century cotton culture in North Carolina had reached the extent of furnishing one-fifth of the people with their clothing. Lawson,² speaking of the prosperity of the country and commending the industry of the women, says:

We have not only provision plentiful, but clothes of our own manufacture, which are made and daily increase, cotton, wool, and flax being of our own growth, and the women are to be highly commended for industry in spinning and ordering their housewifery to so great an advantage as they do.

About this time cotton became widely distributed and cotton patches were common in Carolina. In fact, it is said to have been one of the principal commodities of Carolina as early as 1708, but its culture was only for domestic uses, and the same authority³ speaks of its being spun by the women.

Charlevoix,⁴ in 1722, while on his voyage down the Mississippi, saw "very fine cotton on the tree" growing in the garden of Sieur le Noir, and Captain Roman,⁵ of the British army, saw in East Mississippi black-seeded cotton growing on the farm of Mr. Krebs, and also a machine invented by Mr. Krebs for the separation of the seed and lint. This was a roller gin, and possibly the first ever in operation in this country.

Pickett⁶ says that in 1728 the colony of Louisiana, which at that date occupied nearly all the southwest part of the United States, including Louisiana, Mississippi, and Alabama, was in a flourishing condition, its fields being cultivated, by more than 2,000 slaves, in cotton, indigo, tobacco, and grain.

¹ French's Historical Collections of Louisiana and Florida.

² History of North Carolina, p. 142.

³ Oldmixon, The British Empire in America, 1708, p. 376.

⁴ Louisiana Historical Collections, p. 159.

⁵ Clayborn's Mississippi as a Province, Territory, and State, p. 142.

⁶ History of Alabama, Vol. I, p. 274.

Peter Purry, the founder of Purryville, in South Carolina, in his description of the Province of South Carolina, drawn up in Charleston in 1731, says: "Flax and cotton thrive admirably."

In 1734 cotton seed was planted in Georgia, being sent there by Philip Nutter, of Chelsea, England. Francis Moore,¹ who visited Savannah in 1735, in his description of that place, says:

At the bottom of the hill, well sheltered from the north wind and in the warmest part of the garden, there was a collection of West Indian plants and trees, some coffee, some cocoanuts, cotton, etc.

About the same time the settlers on the Savannah River, about 21 miles north of Savannah, are said to have experimented with cotton, the date being fixed by McCall² as 1738.

One of the striking features connected with the early culture of cotton in the American colonies is that it was grown as far north as the thirty-ninth degree of latitude. Trench Coxe, of Philadelphia, who contributed so greatly to the early success of the culture and manufacture of cotton in the United States, says:

It is a fact well authenticated to the writer that the cultivation of cotton on the garden scale, though not at all as a planter's crop, was intimately known and thoroughly practiced in the vicinity of Easton, in the county of Talbot, on the eastern shore of the Chesapeake Bay, Maryland, as early as 1736.

Its cultivation was so well understood in this part of the country that, according to the same authority, the necessities of the Revolutionary war occasioned it to be raised for army use in the counties of Cape May, New Jersey, and Sussex, Delaware, and it continued to be raised, though only in small quantities for family use. At the time of the Revolution the home-grown cotton was sufficiently abundant in Pennsylvania to supply the domestic needs of that State. Cotton was also cultivated in Charles, St. Marys, and Dorchester counties, Maryland as late as 1826.³ And at a later date (1861-1864) upland cotton was cultivated, and at the prices current at that date was a most profitable crop on the eastern shore of Maryland. Cotton was grown with very good results in Northampton County, on the eastern shore of Virginia, in those years.

The culture and improvement of cotton had received considerable attention by the planters of South Carolina and Georgia as early as 1742. In 1739 Samuel Auspourguer⁴ attested under oath that the "climate and soil of Georgia are very fit for raising cotton."

William Spicer also certified to the adaptability of the country for cotton production, and that he had "brought over with him (to London) several pods of cotton which grew in Georgia."

A tract entitled "A state of the Province of Georgia, attested under oath in the court of Savannah," published in 1740, says of cotton that

¹ Georgia Historical Collection, Vol. I, p. 100.

² History of Georgia, Vol. I, p. 199.

³ Meyer's Register, 1826.

⁴ Georgia Historical Collection, Vol. II, p. 196.

"large quantities had been raised, and it is much planted; but the cotton, which in some parts is perennial, dies here in the winter; nevertheless the annual is not inferior to it in goodness, but requires more trouble in cleansing from the seed."¹ In the same tract it was "proposed that a bounty be settled on every product of the land, viz, corn, peas, potatoes, wine, silk, cotton," etc. In "A description of Georgia, by a gentleman who has resided there upward of seven years and was one of the first settlers," published in London in 1741, the author states that "the annual cotton grows well there, and has been by some industrious people made into clothes."

Samuel Seabrook, in "An important inquiry into the state and utility of Georgia," published in 1741, says: "Among other beneficial articles of trade which it is found can be raised there, cotton, of which some has also been brought over as a sample, is mentioned." In his description of St. Simons Island the same author says:

The country is well cultivated, several parcels of land not far distant from the camp of General Oglethorpe's regiment having been granted in small lots to the soldiers, many of whom are married. * * * The soldiers raise cotton and their wives spin it and knit it into stockings.

A publication in London in 1762 says: "What cotton and silk both the Carolinas send us is excellent and calls aloud for encouragement of its cultivation in a place well adapted to raise both."²

Captain Robinson, an Englishman who visited the coast of Florida in 1754, says the "cotton tree was growing in that country." The Florida Territory then extended from the Atlantic to the Mississippi River. That it was cultivated in East Florida about ten years after this is evidenced by William Stork, who says: "I am informed of a gentleman living upon the St. Johns that the lands on that river below Piccolata are in general good, and that there is growing there now (1765) good wheat, Indian corn, indigo, and cotton."³

Cotton early attracted the attention of the French colonists in Louisiana. In the year 1752 Michel,⁴ in a report to the French minister on the condition of the country, gave interesting details of the cultivation of cotton and the difficulty found in separating the wool from the seed.

In 1758 white Siam seed was introduced into Louisiana. Du Prate says: "This East India annual plant has been found to be much better and whiter than what is cultivated in our colonies, which is of the Turkey kind."

Letters from Paris to Governor Roman state that there is among the French archives at Paris, Department of Marine and Colonies, a most curious and instructive report on cotton in 1760.⁵ It was found to be a very profitable crop in Louisiana, for in the year 1768 the French planters, in a memoir to their Government, complained that the parent Gov-

¹ Patent Office Reports, Vol. VII, 1853, 1854.

² Bishop's History of American Manufacture.

³ Stork's Description of East Florida; London, 1765.

⁴ De Bow's Review, Vol. I, p. 439.

⁵ De Bow's Review, Vol. I, p. 300.

ernment had turned them over to the Spaniards just "at the time when a new mine had been discovered; when the culture of cotton, improved by experience, promises the planter a recompense of his toils, and furnishes persons engaged in fitting out vessels with the cargoes to load them."

In 1762 Captain Bossu,¹ of the French marines, said: "Cotton of this country (Louisiana) is of the species called the white cotton of Siam. It is neither so fine nor so long as the silk cotton, but it is, however, very white and very fine."

In 1775 the provincial congress of South Carolina recommended the cultivation of cotton, and in the same year a similar enactment was passed by the Virginia assembly, which declared that "all persons having proper land ought to cultivate and raise a quantity of hemp, flax, and cotton, not only for the use of their own families, but to spare to others on moderate terms." This legislation no doubt was suggested on account of the changed relations of the colonies with Great Britain.

In 1786 Thomas Jefferson,² in a letter, says:

The four southernmost States make a great deal of cotton. Their poor are almost entirely clothed with it in winter and summer. In winter they wear shirts of it and outer clothing of cotton and wool mixed. In summer their shirts are linen, but the outer clothing cotton. The dress of the women is almost entirely of cotton, manufactured by themselves, except the richer class, and even many of these wear a great deal of homespun cotton. It is as well manufactured as the calicoes of Europe.

At the convention at Annapolis in 1786 James Madison expressed the conviction that from the experience already had "from the garden practice in Talbot County, Md., and the circumstances of the same kind abounding in Virginia, there was no reason to doubt that the United States would one day become a great cotton-producing country." This year Sea Island cotton seed was introduced into Georgia, the seed being sent from the Bahama Islands to Governor Tatnall, William Spaulding,³ Richard Leake, and Alexander Pisset, of that State. The cotton adapted itself to the climate, and every successive year from 1787 saw long-staple cotton extending itself along the shores of South Carolina and Georgia.

According to Thomas Spaulding, the first planter who attempted cotton culture on a large scale was Richard Leake, of Savannah, but the editor of *Niles Register* (1824) says that Nichol Turnbull, a native of Smyrna, was the first planter who cultivated cotton upon a scale for exportation. His residence was at Deptford Hall, 3 miles from Savannah, where he died in 1824.

In a letter, dated Savannah, December 11, 1788, to Col. Thomas Proctor, of Philadelphia, Leake says:

I have been this year an adventurer (and the first that has attempted it on a large scale) in introducing a new staple for the planting interests—the article of cotton—samples of which I beg leave now to send you and request you will lay them before

¹Travels through the Province of North America called Louisiana.

²Notes on the State of Virginia, 1781.

³Thomas Spaulding in *Niles Register*, 1828.

the Philadelphia Society for Encouraging Manufactures, that the quality may be inspected. Several here, as well as in North Carolina, have followed me and tried the experiment, and it is likely to answer our most sanguine expectations. I shall raise about 5,000 pounds in the seed from 8 acres of land, and next year I intend to plant about 50 to 100 acres if suitable encouragement is given. The principal difficulty that arises to us is the cleansing it from the seed, which I am told they do with great dexterity and ease in Philadelphia with gins or machines made for the purpose. * * * I am told they make those that will clean 30 to 40 pounds clean cotton in a day and upon very simple construction.

The first attempt in South Carolina to produce Sea Island cotton was made in 1788 by Mrs. Kinsey Burden at Burdens Island. As early as 1779 the short staple was produced by her husband, whose negroes were clothed in homespun cotton cloth. Mrs. Burden's efforts failed. The plants did not mature, and this was attributed to the seed, which was of the Bourbon variety. The first successful variety appears to have been grown by William Elliot on Hilton Head, near Beaufort, in 1790, with $5\frac{1}{2}$ bushels of seed, which he bought in Charleston and for which he paid 14s. a bushel. He sold his crop for $10\frac{1}{2}$ d. a pound.

In 1791 John Scriven, of St. Lukes Parish, planted 30 to 40 acres on St. Marys River. He sold it for from 1s. 2d. to 1s. 6d. per pound. It is certain that at this period many planters on the Sea Islands and contiguous mainland experimented with long-staple cotton, and probably it was produced by them for market.

One of the earliest reports of export of cotton from the Colonies is a bill of lading which certifies that on July 20, 1751, Henry Hansen shipped, "in good order and well conditioned, in and upon the good snow called the *Mary*, whereof is master under God, for this present voyage, Baraaby Badgers, and now riding in the harbour of New York, and by God's grace bound for London—to say—eighteen bales of cotton wool, being marked and numbered as in the margin,¹ and are to be delivered in like good order, and conditioned, at the aforesaid port of London (the danger of the sea only excepted), unto Messrs. Horke and Champior or their assigns, he or they paying freight for the said goods, three farthings per pound primage and average accustomed."

The feeling regarding the culture and manufacture of cotton in the Colonies at this period may be gathered from the following extract from a letter of July 7, 1749, addressed by the Georgia office of London to the governor of Georgia:

You say, sir, likewise in your letter, that the people of Vernounburgh and Aeton are giving visible appearance of revising their industry; that they are propagating large quantities of flax and cotton, and that they are provided with weavers, who have already wove several large pieces of cloth of a useful sort, whereof they sold divers, and some they made use of in their own families. The account of their industry is highly satisfactory to the trustees; but as to manufacturing the produce they raise, they must expect no encouragement from the trustees, for setting up manufactures which may interfere with those of England might occasion complaints here, for which reason you must, as they will, discountenance them; and it is necessary for you to direct the industry of these people into a way which might

¹Five bales marked III, No. 1 to 5; 13 bales marked II, No. 1 to 13.

be more beneficial to themselves and would prove satisfactory to the trustees and the public; that is, to show them what advantages they will reap from the produce of silk, which they will receive immediate pay for, and that this will not interfere with or prevent their raising flax or cotton, or any other produces for exportation, unmanufactured. * * *

A pamphlet entitled *A Description of South Carolina* states that cotton was imported to Carolina from the West Indies, and it is probable that the early shipments from this country were of this West Indian cotton, although English writers mentioned it as an import of Carolina cotton.¹

Donnell says:

The first regular exportation of cotton from Charleston was in 1785, when one bag arrived at Liverpool, per ship *Diana*, to John and Isaac Teasdale & Co. The exportation of cotton from the United States could not have been much earlier, for we find in 1784 eight bags shipped to England were seized on the ground of fraudulent importation,² as it was not believed that so much cotton could be produced in the United States.

The exportation during the next six years was successively 6, 14, 109, 389, 842, and 81 bags.³

Dana gives⁴ the following data concerning the export movement from 1739 to 1793:

1739.—Samuel Anspourguer, a Swiss living in Georgia, took over to London, at the time of the controversy about the introduction of slaves, a sample of cotton raised by him in Georgia. This we may call, in the absence of a better starting point, the first export.

1747.—During this year several bags of cotton, valued at £3 11s. 5d. per bag, were exported from Charleston. Doubts as to this being of American growth have been expressed, but as cotton had been cultivated in South Carolina for many years there does not seem to be any reason for such doubts. Besides, English writers mention it is an import of Carolina cotton.

1753.—“Some cotton” is mentioned among the exports of Carolina in 1753, and of Charleston in 1757. * * *

1764.—Eight (8) bags of cotton imported into Liverpool from the United States.

1770.—Three (3) bales shipped to Liverpool from New York; ten (10) bales from Charleston; four (4) from Virginia and Maryland, and three (3) barrels from North Carolina.

1784.—About fourteen (14) bales shipped to Great Britain, of which eight (8) were seized as improperly entered. [See above.]

1785.—Five (5) bags imported at Liverpool.

1786.—Nine hundred (900) pounds imported into Liverpool.

1787.—Sixteen thousand three hundred and fifty (16,350) pounds imported into Liverpool.

1788.—Fifty-eight thousand five hundred (58,500) pounds imported into Liverpool.

1789.—One hundred and twenty-seven thousand five hundred (127,500) pounds imported into Liverpool.

¹ Cassel's Cotton Culture in the Bombay Presidency.

² The laws of England at that time required imports to be in ships of the country from which the product was exported.

³ Donnell's History of Cotton, p. 9.

⁴ Cotton from Seed to Loom, p. 24.

- 1790.—Fourteen thousand (14,000) pounds imported into Liverpool. We can find no reason for this marked decline in the exports except it may be that the crop was a failure that year. Our first supposition was that the cause was one of price, but on examining the quotations in Took's work on "high and low prices" we do not see any marked decline in the values of other descriptions of cotton, and the American staple is not given in his list until 1793.
- 1791.—One hundred and eighty-nine thousand five hundred (189,500) pounds imported into Liverpool, the price averaging here 26 cents.
- 1792.—One hundred and thirty-eight thousand three hundred and twenty-eight (138,328) pounds imported into Liverpool.

Great difficulty was experienced in separating the seed from the lint of upland cotton. The work was done by hand, the task being 4 pounds of lint cotton per week from each head of a family, in addition to the usual field work. This would amount to one bale in two years. A French planter of Louisiana (Dubreuil) is said to have invented a machine for separating lint and seed as early as 1742. The demand for such a machine not being very great at that date, no record as to its character has been preserved. The roller gin, in very much the same form as Nearchus, the admiral of Alexander the Great, found it in India, was still in use. In 1790 Dr. Joseph Eve, originally from the Bahamas, but then a resident of Augusta, Ga., made great improvements on this ancient machine, and adapted it to be run by horse or water power. A correspondent of the American Museum, writing from Charleston, S. C., in July of that year, states "that a gentleman well acquainted with the cotton manufacture had already completed and in operation, on the high hills of Sautee, near Statesburg, ginning, carding, and other machines driven by water, and also spinning machines with eighty-five spindles each, with every article necessary for manufacturing cotton." A machine dating anterior to this year, and having a strong resemblance to the above, possessing in fact all the essentials of a modern cotton gin, was exhibited at the Atlanta Exposition in 1882. It came from the neighborhood of Statesburg, but its history could not be ascertained.

In 1793 Eli Whitney petitioned for a patent for the invention of the saw cotton gin. His claims were disputed, and he defended them in the State and Federal courts for nearly a generation, obtaining at last a verdict in his favor. Meanwhile the saw gin had become an established fact, and the planter at last had a machine which enabled him to produce cotton at a cost that would leave him a good profit. The first saw gin to be run by water power was erected in 1795 by James Kincaid near Monticello, in Fairfield County, S. C. Others were put up near Columbia by Wade Hampton, sr., in 1797, and in the year following he gathered and ginned from 600 acres 600 bales of cotton.

The cotton exportation from the United States increased from 487,600 pounds in 1793 to 1,600,000 pounds in 1794, the year in which Whitney's gin was patented. In 1796, a year after he had improved his machine, the production had risen to 10,000,000 pounds. In fact, the increased production was so great that the planters began to fear they would

overstock the market, and one of them, upon looking at his newly gathered crop, exclaimed: "Well, I have done with cultivation of cotton; there's enough in that ginhouse to make stockings for all the people in America." Yet the production of cotton did not advance with that rapidity to which we are now accustomed.

The cotton industry being of secondary importance prior to 1790, information and statistics relative to the amount produced are not available, but the following table¹ gives the production at different dates from that time to 1895:

Cotton crops of the United States at stated periods.

[Expressed in bales of 400 pounds net.]

Season.	Bales.	Season.	Bales.
1790-91.....	5,000	1859-60.....	5,602,639
1791-92.....	7,500	1865-66.....	2,501,921
1796-97.....	27,500	1869-70.....	3,434,806
1800-01.....	120,000	1873-74.....	4,629,131
1801-02.....	137,500	1878-79.....	5,670,368
1806-07.....	200,000	1880-81.....	7,596,613
1811-12.....	187,500	1884-85.....	6,562,090
1816-17.....	325,000	1887-88.....	8,227,178
1821-22.....	525,000	1890-91.....	10,231,696
1826-27.....	792,150	1891-92.....	10,684,336
1834-35.....	1,150,846	1893-94.....	8,946,533
1840-41.....	1,610,430	1894-95.....	11,466,186
1850-51.....	2,552,620	1895-96.....	7,976,045
1855-56.....	3,838,335		

Within one hundred years, from 1790 to 1890, the production of cotton in the United States increased from 5,000 bales to over 10,000,000 bales. The crop of 1894-95 exceeded that of 1878-79 by nearly 6,000,000 bales, or over 100 per cent increase in sixteen years.

The following tables show the cotton acreage for the years 1878 to 1896, inclusive, and the estimated production and exportation of Sea Island cotton for the years 1880 to 1894, inclusive:

Acreage in cotton in the United States: 1878 to 1896.

Season.	North Carolina.	South Carolina.	Georgia.	Florida.	Alabama.	Missis- sippi.
	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>
1878-79.....	590,500	944,650	1,483,500	166,650	1,837,550	2,055,050
1879-80.....	625,900	944,600	1,592,000	161,600	1,892,700	2,055,000
1880-81.....	933,000	1,441,600	2,736,300	251,600	2,460,600	2,275,000
1881-82.....	1,061,155	1,619,639	2,994,005	263,032	2,639,988	2,351,228
1882-83.....	1,050,543	1,618,989	2,872,748	257,799	2,610,420	2,278,521
1883-84.....	1,050,543	1,618,989	2,872,748	257,799	2,610,420	2,278,521
1884-85.....	1,061,048	1,716,128	2,958,930	268,111	2,740,941	2,392,447
1885-86.....	1,071,658	1,733,289	3,047,698	273,473	2,795,760	2,535,994
1886-87.....	1,071,658	1,655,291	2,956,267	270,738	2,823,718	2,548,674
1887-88.....	1,066,301	1,622,185	2,941,486	262,616	2,809,599	2,548,674
1888-89.....	1,071,633	1,646,518	2,970,901	259,990	2,851,743	2,592,001
1889-90.....	1,147,136	1,987,469	3,345,104	237,370	2,761,165	2,883,278
1890-91.....	1,036,026	1,682,522	3,086,682	280,147	3,096,232	2,965,614
1891-92.....	1,014,270	1,663,997	2,991,027	271,467	3,000,282	2,903,327
1892-93.....	833,695	1,482,222	2,841,580	214,017	2,607,616	2,571,684
1893-94.....	1,180,000	1,885,000	3,050,000	165,000	2,316,000	2,845,400
1894-95.....	1,296,522	2,160,391	3,610,968	201,621	2,664,861	2,826,272
1895-96.....	1,050,183	1,814,728	3,069,323	191,540	2,371,726	2,487,119
1896-97.....	1,228,714	2,014,348	3,468,335	264,325	2,656,333	2,835,316

¹ Except where otherwise stated, the statistics used in this article are taken mainly from Rpt. U. S. Senate Com. on Agr. and Forestry, Feb. 23, 1895; Shepperson's Cotton Facts, 1895, and reports of the Bureau of Statistics, U. S. Treasury.

Acreage in cotton in the United States: 1878 to 1896—Continued.

Season.	Louisiana.	Texas.	Arkansas.	Tennessee.	All other.	Total.
	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>	<i>Acres.</i>
1878-79.....	1,348,950	1,808,400	1,165,850	740,700	125,000	12,266,800
1879-80.....	1,322,000	1,935,000	1,177,500	762,900	126,300	12,595,500
1880-81.....	888,000	2,395,100	1,080,200	816,200	147,700	15,475,300
1881-82.....	944,174	2,676,298	1,181,692	840,990	138,529	16,710,730
1882-83.....	931,900	3,034,922	1,188,545	807,602	139,568	16,791,557
1883-84.....	931,900	3,034,922	1,188,545	807,602	126,004	16,777,993
1884-85.....	922,581	3,186,668	1,259,858	813,678	117,222	17,459,612
1885-86.....	1,005,613	3,505,335	1,348,048	864,618	119,379	18,300,865
1886-87.....	1,035,781	3,771,740	1,354,788	847,326	118,622	18,454,603
1887-88.....	1,066,854	3,960,327	1,388,658	855,799	118,568	18,641,067
1888-89.....	1,088,191	4,158,343	1,416,431	881,473	121,367	19,058,591
1889-90.....	1,270,154	3,934,525	1,700,578	747,471	167,646	20,171,896
1890-91.....	1,107,138	4,956,145	1,494,333	995,181	109,033	20,809,053
1891-92.....	1,094,949	5,198,643	1,492,809	964,341	119,825	20,711,937
1892-93.....	897,469	4,431,729	1,247,239	808,235	132,438	18,067,924
1893-94.....	946,000	4,153,760	1,867,250	805,920	310,670	19,525,000
1894-95.....	1,313,296	6,854,621	1,483,319	875,954	396,125	23,687,950
1895-96.....	1,142,568	5,826,428	1,186,655	712,763	331,335	20,184,368
1896-97.....	1,245,399	6,758,656	1,542,652	912,337	518,919	23,445,334

Estimated Sea Island cotton crop of the United States and exports of same since 1880.

Year.	Florida.	Georgia.	South Carolina.	Texas.	Total.	Exports.
	<i>Bales.</i>	<i>Bales.</i>	<i>Bales.</i>	<i>Bales.</i>	<i>Bales.</i>	<i>Bales.</i>
1880-81.....	16,950	3,179	14,868	24	35,021	24,395
1881-82.....	20,992	6,049	10,796	25	37,862	24,756
1882-83.....	16,898	3,126	16,591	94	36,709	23,457
1883-84.....	16,762	1,399	7,329	.....	25,490	13,579
1884-85.....	23,526	4,327	12,588	11	40,452	21,565
1885-86.....	23,501	5,780	8,497	.....	37,778	16,428
1886-87.....	29,991	6,411	8,735	.....	45,137	26,651
1887-88.....	22,614	8,304	8,561	.....	39,479	20,613
1888-89.....	22,471	12,000	9,618	.....	44,089	23,326
1889-90.....	23,918	13,629	9,256	.....	46,803	28,242
1890-91.....	22,214	29,613	16,306	.....	68,133	39,123
1891-92.....	17,059	30,576	11,499	.....	59,134	27,431
1892-93.....	9,882	28,324	7,212	.....	45,418	22,540
1893-94.....	19,107	39,367	2,578	.....	61,052	38,021
1894-95.....	15,031	53,703	5,894	.....	74,628	40,744

The first cotton mill erected in the United States was built at Beverly, Mass., in 1787-88. This was soon followed by others in various towns along the east border of the country, especially Pawtucket and Providence, R. I., Boston, Mass., New Haven and Norwich, Conn., New York City, Paterson, N. J., Philadelphia, Pa., and Statesburg, S. C. In them carding and spinning were done by machinery, but the weaving was on hand looms until 1815, at which date a power-loom mill was started at Waltham, Mass. The use of hand looms and spinning wheels for cotton manufacture was common in all parts of the country before the Revolution, especially in the Southern colonies, and these continued to be used by the women in their houses many years after the erection of cotton factories. *

In 1831 there were in the United States 801 cotton mills, with 33,433 looms and 1,246,703 spindles, employing 62,208 persons and consuming 77,457,316 pounds of raw cotton, with \$40,612,984 capital. In 1860 there were 1,091 mills, with 126,313 looms and 5,235,727 spindles, employing 122,028 workmen, and having \$98,585,269 capital. The raw material used was 422,704,975 pounds, valued at \$57,285,534, and the value of the finished product was \$115,681,774.

During the great "cotton famine" caused by the civil war the production of cotton in the United States practically ceased, and it was not until 1867-68 that the cotton industry regained the position it had held in 1860. From that period until 1880 there was irregular but decided growth in the industry.

The supply and consumption of cotton in the United States from 1791 to 1895 is shown in the following table, compiled by Watkins:¹

Production and consumption of cotton in the United States from 1791 to 1895, inclusive.

Year.	Crop.	Consumption.	Exports.	Stock (close of year).	Net weight of bales.
	<i>Bales.</i>	<i>Bales.</i>	<i>Bales.</i>	<i>Bales.</i>	<i>Pounds.</i>
1790-1791.....	8,889	(a)	889	(a)	225
1791-1792.....	13,333	(a)	635	(a)	225
1792-1793.....	22,222	(a)	2,222	(a)	225
1793-1794.....	35,556	(a)	7,407	(a)	225
1794-1795.....	35,556	(a)	27,822	(a)	225
1795-1796.....	44,444	(a)	27,141	(a)	225
1796-1797.....	48,889	(a)	16,837	(a)	225
1797-1798.....	66,667	(a)	41,600	(a)	225
1798-1799.....	88,889	(a)	42,366	(a)	225
1799-1800.....	155,556	35,556	79,066	(a)	225
1800-1801.....	210,526	39,474	91,716	(a)	228
1801-1802.....	241,228	(a)	120,619	(a)	228
1802-1803.....	252,101	(a)	158,454	(a)	238
1803-1804.....	240,741	(a)	129,756	(a)	270
1804-1805.....	281,128	44,177	154,101	(a)	249
1805-1806.....	347,826	(a)	155,032	(a)	230
1806-1807.....	285,714	(a)	228,362	(a)	280
1807-1808.....	271,739	(a)	38,516	(a)	276
1808-1809.....	366,071	(a)	227,635	(a)	224
1809-1810.....	340,000	64,000	373,046	(a)	250
1810-1811.....	269,360	57,239	208,950	(a)	297
1811-1812.....	304,878	(a)	117,428	(a)	246
1812-1813.....	304,878	(a)	77,683	(a)	246
1813-1814.....	284,553	(a)	72,069	(a)	246
1814-1815.....	363,636	90,000	301,814	(a)	275
1815-1816.....	457,565	(a)	302,388	(a)	271
1816-1817.....	460,993	(a)	303,721	(a)	282
1817-1818.....	448,029	(a)	331,438	(a)	279
1818-1819.....	596,429	(a)	314,275	(a)	280
1819-1820.....	606,061	(a)	484,319	(a)	264
1820-1821.....	647,482	(a)	449,257	(a)	278
1821-1822.....	742,049	(a)	511,219	(a)	282
1822-1823.....	620,805	(a)	582,964	(a)	298
1823-1824.....	762,411	(a)	504,857	(a)	282
1824-1825.....	891,608	(a)	616,958	(a)	286
1825-1826.....	1,121,667	(a)	635,562	(a)	312
1826-1827.....	957,281	149,516	854,000	(a)	331
1827-1828.....	720,593	120,593	600,000	40,000	335
1828-1829.....	870,415	118,853	740,000	30,000	341
1829-1830.....	976,845	126,512	839,000	35,000	339
1830-1831.....	1,038,847	182,142	773,000	119,000	341
1831-1832.....	987,477	173,800	892,000	41,600	360
1832-1833.....	1,070,438	194,412	867,000	48,200	350
1833-1834.....	1,205,394	196,413	1,028,000	29,600	363
1834-1835.....	1,254,328	216,888	1,023,000	41,600	367
1835-1836.....	1,360,725	236,733	1,116,000	43,300	373
1836-1837.....	1,423,930	222,540	1,169,000	75,800	379
1837-1838.....	1,801,497	246,063	1,575,000	40,300	379
1838-1839.....	1,360,532	276,018	1,074,000	52,250	384
1839-1840.....	2,177,835	295,193	1,876,000	58,442	383
1840-1841.....	1,634,954	297,288	1,313,500	72,479	394
1841-1842.....	1,683,574	267,850	1,465,500	31,807	397
1842-1843.....	2,378,875	325,129	2,010,000	94,486	409
1843-1844.....	2,030,409	346,750	1,629,500	159,772	412
1844-1845.....	2,394,503	389,000	2,083,700	98,420	415
1845-1846.....	2,100,537	422,600	1,666,700	107,122	411
1846-1847.....	1,778,651	428,000	1,241,200	214,837	436
1847-1848.....	2,439,786	616,044	1,858,000	171,468	411
1848-1849.....	2,866,938	642,485	2,228,000	154,753	437

a No data.

¹ Production and Price of Cotton for One Hundred Years, U. S. Dept. Agr., Div. of Stat. Misc. Bul. 9.

Production and consumption of cotton in the United States, etc.—Continued.

Year.	Crop.	Consumption.	Exports.	Stock (close of year).	Net weight of bales.
	<i>Bales.</i>	<i>Bales.</i>	<i>Bales.</i>	<i>Bales.</i>	<i>Pounds.</i>
1849-50.....	2,333,718	613,498	1,590,200	167,930	429
1850-51.....	2,454,442	485,614	1,988,710	128,304	416
1851-52.....	3,126,310	689,603	2,443,646	91,176	428
1852-53.....	3,416,214	803,725	2,528,400	135,643	438
1853-54.....	3,074,979	737,236	2,319,148	135,603	430
1854-55.....	2,982,634	706,417	2,244,209	143,336	434
1855-56.....	3,655,557	777,739	2,954,606	64,171	420
1856-57.....	3,093,737	819,936	2,252,657	49,258	444
1857-58.....	3,257,339	595,562	2,590,455	102,926	442
1858-59.....	4,018,914	927,651	3,021,403	149,237	447
1859-60.....	4,861,292	978,043	3,774,173	227,708	461
1860-61.....	3,849,469	843,740	3,127,568	83,127	477
1861-62.....	a4,500,000	a370,000	644,936	(b)	477
1862-63.....	a1,600,000	a288,000	10,898	(b)	477
1863-64.....	b450,000	a220,000	27,053	(b)	477
1864-65.....	b300,000	a345,000	24,787	(b)	477
1865-66.....	2,269,316	666,100	1,554,664	283,692	441
1866-67.....	2,097,254	770,030	1,557,054	80,296	444
1867-68.....	2,519,554	906,636	1,655,816	37,398	445
1868-69.....	2,366,467	926,374	1,465,880	11,160	444
1869-70.....	3,122,551	865,160	2,206,480	65,325	440
1870-71.....	4,352,317	1,110,196	3,169,009	144,290	442
1871-72.....	2,974,351	1,237,330	1,957,314	59,287	443
1872-73.....	3,930,508	1,201,127	2,679,986	104,782	444
1873-74.....	4,170,388	1,305,943	2,840,981	124,795	444
1874-75.....	3,832,991	1,193,005	2,684,708	74,411	440
1875-76.....	4,632,313	1,351,870	3,234,244	130,041	444
1876-77.....	4,474,069	1,428,013	3,030,835	130,493	440
1877-78.....	4,773,865	1,489,022	3,360,254	45,784	450
1878-79.....	5,074,155	1,558,329	3,481,004	65,948	447
1879-80.....	5,761,252	1,789,978	9,885,003	141,418	454
1880-81.....	6,605,750	1,938,937	4,589,346	218,043	460
1881-82.....	5,456,048	1,964,535	3,582,622	124,232	450
1882-83.....	6,949,756	2,073,006	4,766,597	237,117	470
1883-84.....	5,713,200	1,876,683	3,916,581	116,190	462
1884-85.....	5,706,165	1,753,125	3,947,972	132,421	460
1885-86.....	6,575,691	2,162,544	4,336,203	178,026	463
1886-87.....	6,505,087	2,111,532	4,445,302	86,269	464
1887-88.....	7,046,833	2,257,247	4,627,502	180,062	467
1888-89.....	6,938,290	2,314,091	4,742,347	65,624	477
1889-90.....	7,311,322	2,390,959	4,906,627	75,195	478
1890-91.....	8,652,597	2,632,023	5,847,191	215,692	473
1891-92.....	9,035,379	2,876,846	5,933,437	421,104	473
1892-93.....	6,700,365	2,431,134	4,445,338	237,411	475
1893-94.....	7,549,817	2,319,688	5,287,587	180,912	474
1894-95.....	c9,476,435	2,704,153	6,614,619	405,519	484

a Estimated.

b No data.

c Estimate of Department of Agriculture.

The exports of cotton from the United States to Great Britain from 1786 to 1790 averaged only $\frac{1}{636}$ of the total cotton imports of that country, but sixty years later, from 1846 to 1850, the United States supplied four-fifths of Great Britain's demand for cotton. From 1786 to 1790 the average amount of cotton imported by Great Britain from the United States was 100 bales (of 400 pounds each); from 1816 to 1820, 166,310 bales; from 1846 to 1850, 1,297,230 bales; and from 1876 to 1880, 2,589,070 bales. Of the supply of cotton available for the United States and Europe in 1850-51 the United States furnished 2,536,000 bales, or 81 per cent, and although the gross production has so greatly increased since that date that in 1891-92 the United States produced 10,664,000 bales, the proportion of the cotton available for Europe and the United States furnished by the United States has never been greater than 82 per cent (in 1892).

Production and Consumption of Cotton in bales of 400 lb. weight by the Countries contributing to the world's supply and demand for a series of years from 1790 to 1895.

By Harry Hammond.

Scale: 1,000,000 Bales of 400 lb. weight = 1/2 inch.



The following table shows the exports of cotton from the United States for the years noted:

Exports of cotton from the United States to Great Britain and the Continent and Mexico from 1879 to 1894, inclusive.

Year.	To Great Britain.	To the Continent and Mexico.	Total.	Year.	To Great Britain.	To the Continent and Mexico.	Total.
	<i>Bales.</i>	<i>Bales.</i>	<i>Bales.</i>		<i>Bales.</i>	<i>Bales.</i>	<i>Bales.</i>
1878-79.....	2,053,000	1,413,000	3,466,000	1887-88.....	2,814,000	1,813,000	4,627,000
1879-80.....	2,554,000	1,310,000	3,864,000	1888-89.....	2,810,000	1,926,000	4,736,000
1880-81.....	2,832,000	1,733,000	4,565,000	1889-90.....	2,854,000	2,052,000	4,906,000
1881-82.....	2,295,000	1,256,000	3,551,000	1890-91.....	3,345,000	2,446,000	5,791,000
1882-83.....	2,886,000	1,838,000	4,724,000	1891-92.....	3,317,000	2,541,000	5,858,000
1883-84.....	2,485,000	1,432,000	3,917,000	1892-93.....	2,301,000	2,089,000	4,390,000
1884-85.....	2,425,000	1,495,000	3,920,000	1893-94.....	2,861,000	2,371,000	5,252,000
1885-86.....	2,565,000	1,771,000	4,336,000	1894-95.....	3,449,000	3,279,000	6,726,000
1886-87.....	2,704,000	1,741,000	4,445,000				

COTTON IN INDIA.

India ranks, and perhaps always will rank, next to the United States as a cotton-producing country. With an area of 1,367,000 square miles, lying south of the thirty-fifth degree of north latitude and wholly within the cotton belt, India is twice the size of that part of the United States known as the Cotton States, and possesses a good cotton soil, although hampered by an uncertain and discouraging climate. Bounded on the east, north, and west by mountains, with mountain chains traversing the central territory, and subject to two periodical wet seasons, portions of her territory are rendered unfit for cotton growing, either by excessive rainfall, which in some sections amounts to 500 inches per annum, or by the lack of moisture in others, where the annual rainfall is scarcely an inch. Although cotton had been cultivated there for fully 4,000 years, the increase in production was but slight until stimulated by the diminished supply from the United States between 1861 and 1865. During the cotton famine of this period the cultivation was pushed to its utmost extent, but when the United States regained its supremacy in cotton culture the production of cotton in India was not pressed with so much vigor. At present the attention of the ryots has been turned to the production of the more profitable indigo and linseed, and it is probable that the production of cotton will further decrease. The average yield in India varies in the different provinces from 40 to 100 pounds of clean cotton per acre, dependent on the seasons.

British India, or Hindostan, the part of India where cotton is raised, embraces four principal cotton regions: The valley of the Ganges, the Deccan, western India, and southern India.

The Ganges Valley is again divisible into two parts, the Lower Bengal district, and that of the northwest provinces, including Doab and Bundelcund, lying on both sides of the Ganges and Jumna rivers.

In Lower Bengal the cultivation of cotton is not of very great importance. In the plains of Bengal, which are so fertile in other produce, the production of cotton is very inconsiderable, and none is exported.

The cotton raised here in former times, though short in staple, was the finest known in the world, and formed the material out of which the very delicate and extremely beautiful Dacca muslin was manufactured. This interesting and indefinite variety of *Gossypium herbaceum* is known as Dacca cotton, and what little is raised is used at home in the looms of a few weavers at Bazitpore and Polsia and seldom finds its way to Calcutta.

The border lands of the Ganges are too low and marshy and the rainfall too great for the successful cultivation of cotton, but the hills back from the river are suitable for this purpose, as they are better drained.

The Doab and Bundelcund districts produce almost the entire crop of the northwest provinces, and furnish about 70,000,000 pounds of cotton for exportation, which is a good "India cotton." The climatic character of these districts is "first a flood and then a drought," with an inclination to an insufficiency of rain, in great contrast to that of Lower Bengal.

The Deccan, or Central India, is the great cotton section of India. It occupies the triangular area lying south of the Vindhyan Mountains, in latitude 23° north, and extends to the valley of the Kistna, at 16° north, with the Eastern and Western Ghats on either side. It is an elevated table-land of undulating surface, having soil of great excellence and richness and of a consistency to retain moisture for a long time. Nearly all the cotton for export is raised within this region and finds its market at Bombay.

The Deccan may be divided into the Nagpore, Hyderabad, Berar, and Dharwar districts.

The soil in the valleys of Nagpore is a rich black loam which becomes very sticky and muddy during the rainy season and hard and cracked during the dry season, in this respect very much resembling some of the Alabama soils. In the hilly portion there is a red clay soil. The cotton grown within this district is very fine and soft, indicative of a moist and equable climate, especially that produced in the valleys of the Wurda and its tributaries. It is known commercially as "Hinganghat cotton," from the chief town of that section, and is considered as possessing the highest qualities of any India cotton.

Hyderabad is a plateau with a surface more or less hilly and a general elevation of 2,000 feet above sea level. The soil between the hills is remarkably fertile, and along the Kistna, Godavery, and Wurda rivers and their tributaries is to be found some of the most productive soil of India.

Berar is an elevated valley through which flow several large streams that enter into the Godavery and drain a country the soil of which is unsurpassed in richness and depth and adaptability to the cultivation of cotton. From this section comes the cotton known as "Oomrawattee," or Oomras.

Dharwar is another good cotton district, being especially suited to the acclimatizing and culture of American cotton. The extent of

territory is small, but being near the sea and possessing a tolerable uniformity of atmospheric moisture, the combination of climate and soil is better adjusted for the production of cotton than any other part of the Deccan, and consequently than any other region of India.

Western India is of no special interest in this connection, not being a heavy producer of cotton except in the provinces of Scinde, Cutch, and Guzerat. The soil of these provinces varies in richness and productiveness from sand to deep black alluvium. The greatest drawback to the cultivation of cotton in this region is the extreme heat and the drought succeeding a rainy season of small precipitation—3 to 10 inches in Scinde and Cutch, though parts of Guzerat have a yearly fall of 40 inches.

Southern India, or the southern part of the Madras Presidency, is best represented in cotton culture by the provinces of Coimbatore and Tinnevely, which border on the Western Ghauts, where the atmosphere is humid. The cotton raised in the latter province is the best grown in southern India.

Although India has always produced large quantities of cotton, and made most beautiful and delicate webs from its fiber, exporting these fabrics to all parts of the world, it is only within the past one hundred years that she has exported any considerable quantity of raw cotton.

The Secretary of the Treasury of the United States in 1836 estimated the cotton crop of India for 1801 at 400,000 bales of 400 pounds each; but of this amount, according to Watt and Murray,¹ "the imports into Great Britain from India during the years 1800 to 1809 averaged 12,700 bales per annum," and "in 1818 the export to the United Kingdom amounted to 247,000 bales—the largest quantity exported from India up to 1833—but in 1821 had fallen to 20,000 bales."

The estimated yield of cotton in India for 1834 was 463,000 bales of 400 pounds each, showing but a slight increase over the production in 1801, and indicating that the increased exportation from that country was at the expense of home consumption, caused by some falling off of the American crop and not an equal increase in production.

"The final result of the contest between America and India in cotton supply," says Watt, "is too well known to require any recapitulation. America had gained command of the market, and India was considered only as a supplementary source of supply, resorted to mainly in the event of a short crop in the West."

The following table gives the production of cotton in India from 1869 to 1894:

Production of cotton in India, by periods (in bales of 400 pounds).

Year.	Bales.	Year.	Bales.
1869-70.....	1,985,000	1891-92.....	2,795,000
1880-81.....	2,093,000	1892-93.....	2,902,000
1890-91.....	3,225,000	1893-94.....	2,993,000

¹ Watt, Dictionary of Economic Products of India, IV, p. 48.

Important and interesting as are the Indian manufactures of cotton it is impossible in this publication to do more than briefly sketch their progress. The total number of hand looms in the country and the amount of raw material they consume are quite large, but it is impossible to give accurate figures for either. As the power mills of India increased and importation of foreign goods was augmented, the finer fabrics of the hand loom, such as Dacca muslin, once so famous all over the world, ceased to be produced, until now they are rarely seen, and the present generation of weavers, from lack of demand for their product, have almost lost the art which, transmitted from father to son for 4,000 years, had placed them easily first among the weavers of the world.

The first mill built in India was opened for business at Bombay in 1854. This was followed by another in 1855, and by a third in 1857. In 1861 there were 12, with 338,000 spindles and an estimated annual consumption of 65,000 bales of 390 pounds to the bale.¹

In 1879, twenty-five years after the erection of the first mill, the number had increased to 56, with 1,500,000 spindles.

In 1889 there were 124 mills, working 21,600 looms, 2,763,000 spindles, employing 91,600 hands, and consuming 888,700 bales of raw cotton. Three-fourths of this consumption was by mills in Bombay Presidency; Bengal Presidency being second, using 85,000 bales, and Madras Presidency third, working up 43,750 bales.

In 1893-94 India mills took 1,222,000 bales of 400 pounds net for consumption, about 41 per cent of her crop. The amount used outside of the mills was sufficient to bring the total home consumption up to a little over 50 per cent of the crop for that year. India is also a large buyer of cotton yarns and cloth, as in 1892 she imported 50,404,318 pounds of cotton yarn and twist, valued at \$6,380,000, and cotton manufactures valued at \$52,867,000.

India less than twenty-five years ago took 1½ per cent of all cotton grown and now consumes 10 per cent.

The growth of cotton manufacture in India since 1861 is shown by the following statistics:

Cotton mills of India.

[Compiled by the secretary of the subcommittee from the annual reports of the Bombay Mill Owners' Association.]

Year ending June 30—	Number of mills.	Number of spindles.	Estimated annual con- sumption (in bales of 392 lbs.).	Year ending June 30—	Number of mills.	Number of spindles.	Estimated annual con- sumption (in bales of 392 lbs.).
1861.....	12	338,000	65,000	1885.....	87	2,145,646	596,749
1874.....	27	593,000	114,000	1886.....	95	2,261,561	643,204
1875.....	40	886,000	170,000	1887.....	103	2,421,290	726,276
1876.....	47	1,100,112	198,000	1888.....	114	2,488,851	786,982
1877.....	51	1,244,206	215,000	1889.....	124	2,762,518	888,654
1878.....	53	1,289,706	225,000	1890.....	137	3,274,000	1,008,000
1879.....	56	1,452,794	267,585	1891.....	134	3,352,000	1,179,000
1880.....	56	1,461,590	307,631	1892.....	139	3,402,000	1,166,000
1881.....	57	1,513,096	378,989	1893.....	141	3,576,000	1,122,000
1882.....	65	1,620,814	397,562	1894.....	142	3,650,000	1,140,000
1883.....	67	1,790,388	456,556	1895.....	148	3,810,000	1,342,000
1884.....	79	2,001,667	531,365				

About 125,000 persons are now employed in the mills.

¹ Watt, Dictionary of Economic Products of India, IV, p. 158.

COTTON IN EGYPT.

From time immemorial a fine quality of cotton has been grown in the upper regions of the Nile, particularly in Abyssinia. Seed of this variety was brought to Lower Egypt about 1820, and from about this date Egypt has been a regular exporter of cotton to European markets. From 1821 to 1856 the quantity varied from 15,000,000 to 50,000,000 pounds annually; but Egypt felt the stimulus of the cotton famine of 1861-1865, which caused all cotton-growing countries to increase their yield.

In 1860 the export duty of 10 per cent levied by the Government had been reduced to 1 per cent, and this also stimulated the culture, and the annual average export for the decade 1861-1870 was 310,000 bales of 400 pounds each. Unlike other cotton-growing countries, Egypt did not reduce its cotton production upon the resumption of shipments from America, but has steadily increased its output, as will be seen from the following table:

Exports of cotton from Egypt to Europe and the United Kingdom.

Year.	Bales.	Year.	Bales.	Year.	Bales.
1874.....	410, 000	1882.....	423, 000	1889.....	388, 000
1875.....	347, 000	1883.....	329, 000	1890.....	433, 000
1876.....	472, 000	1884.....	384, 000	1891.....	538, 000
1877.....	438, 000	1885.....	500, 000	1892.....	620, 000
1878.....	400, 000	1886.....	410, 000	1893.....	678, 000
1879.....	255, 000	1887.....	418, 000	1894.....	664, 000
1880.....	456, 000	1888.....	411, 000	1895.....	634, 000
1881.....	405, 000				

According to Foaden¹ the present production in Egypt is about 577,500,000 pounds of fiber, practically the whole of which is exported; and 22,275,000 bushels of seed, of which the greater part is exported.

Extensive irrigation and drainage systems are in course of construction which will doubtless greatly increase the area of cotton culture. Moreover, other crops are being abandoned to some extent and cotton substituted for them.

Mako-Jumel, the name given the variety of cotton first cultivated experienced many changes and evolutions in Egypt, gradually changing its color to a yellowish brown, and this new variety was known as Ashmouni, from the valley of Ashmoun, where this change was first noted. The principal varieties of Egyptian cotton are the Ashmouni, Mitaffi, Bamia, Abbasi, and Gallini. For many years the Ashmouni formed the bulk of the Egyptian crop, but it is now almost entirely superseded by the Mitaffi. In color it is a lightish brown and its staple is over an inch in length. Its cultivation is continued in some parts of Egypt, but the acreage of this variety is decreasing every year. In Upper Egypt, however, it is more extensively cultivated, the soil there being less favorable to Mitaffi.

¹ Foaden, MS. article on cotton culture in Egypt, in the possession of this Office.

The Mitafifi cotton was discovered by a Greek merchant in the village of that name. The seed has a bluish-green tuft at the extremity, which attracted the merchant's attention, and on planting it he found that it possessed decided advantage over the old Ashmouni. It is more hardy and also yields a greater proportion of lint to the seed. At first from 315 pounds of seed cotton 112 pounds of lint was secured, and sometimes even more. It is now somewhat deteriorated and rarely yields so much, averaging about 106 pounds of lint to 315 of seed cotton. The Mitafifi is a richer and darker brown than the Ashmouni. The fiber is long, very strong, and fine to the touch, and is in great demand. In fact it controls the market.

Next to Mitafifi, Bamia is perhaps the most extensively cultivated variety in Lower Egypt. It was discovered by a Copt in 1873. The plant is of large size and coarse growth. It is later and less hardy than Mitafifi, and the fiber is poor as compared with that of Mitafifi and Abbasi, light brown in color, and not very strong. In general it may be said that this variety is inferior to Mitafifi in yield, hardiness, and length and strength of fiber.

Abbasi is a variety of recent introduction and is not yet very extensively grown. It was derived from the Mitafifi through the Zafiri. It resembles Mitafifi, but is somewhat earlier. "The lint is of a beautiful white color, fine, silky, very long, though not so strong as Mitafifi, and the first two pickings command the highest price in the market."¹

The Gallini cotton, derived from Sea Island and closely resembling it, has almost entirely disappeared from cultivation, as the quality has deteriorated to such an extent that it is difficult to sell. In 1891 only 122 cantars (less than 20 bales) were on the market, and they were not readily sold.

Among other varieties may be named Hamouli, of a good mellow brown color, not so long in staple as the Mitafifi, but producing a good proportion of lint

From 1879 to 1894, on the State domains, the average yield per acre was 425 pounds, valued at \$42.59 per acre; from 1890 to 1894, inclusive, the yield of cotton gave on an average \$43.14 per acre. During the three years 1892, 1893, and 1894 the money yield, including value of cotton seed, lint, and wood (stubble), has averaged \$52 per acre. The cotton seed brings about \$4.50 per acre. The wood is valued at about \$2.50 per acre, being used as fuel.

Foaden gives the following estimate of the present cost of growing an acre of cotton in Egypt:

Cost per acre of growing cotton in Egypt.

Rent of land, including taxes	\$27.00
Irrigation	7.00
Preparation of land, seeding, manuring, etc	5.50
Cost of seed .....	.50
Cultivation, including hoeing, thinning, etc	2.00
Picking	4.00
Total	46.00

¹ Foaden, *loc. cit.*

The return from lint, seed, etc., is stated by him to be \$66, thus yielding a profit of \$20 per acre.

A small Arab farmer who works his crop with his family can produce cotton much cheaper. The average yield of lint cotton per acre is 340 pounds, but good lands produce 700.¹

The cotton gins in use in Egypt are of the roller pattern, there being about 100 ginning mills in the country, distributed in all the chief cotton centers. There are also hydraulic presses attached to nearly all the mills, so that the cotton comes to Alexandria, the shipping point, hydraulically pressed. There are but few steam press mills in the country, so that the great business of preparing for exportation is confined to Alexandria.

The Egyptian cotton is put up in close, compact, tough covering. The bales, which are long and smooth, weigh from 700 to 780 pounds, occupy from 15 to 20 cubic feet each, are plainly marked, and are wrapped close and bound strong and tight. Being so well covered and bound, injury from fire, water, dirt, and dust is minimized. Ships which can pack 10,000 or 12,000 bales of Egyptian cotton can take only from 6,000 to 8,000 bales of American cotton, although, according to the ratio of weights, they should take 14,000 bales. As it is, the cost of freighting is much heavier for American cotton per pound than for the Egyptian, and there is much waste in unnecessary packing material, and loss by dirt, mud, and bursting of bales, which affect about equally the producer and the manufacturer.

Egyptian cotton is not as fine as Sea Island cotton, and of course does not bring so high a price, but is better than American upland cotton for goods requiring smooth finish and high luster. It gives to fabrics a soft finish somewhat like silk. It has a strong, silky staple from $1\frac{1}{8}$ to $1\frac{1}{2}$ inches in length.

The imports of Egyptian cotton into the United States for the seasons ending August 31 were at different periods as follows:

Imports of Egyptian cotton into the United States.

Year.	Bales.	Year.	Bales.
1884-85.....	4,553	1890-91.....	23,790
1885-86.....	3,815	1891-92.....	27,739
1886-87.....	4,700	1892-93.....	42,475
1887-88.....	5,792	1893-94.....	33,606
1888-89.....	8,430	1894-95.....	59,418
1889-90.....	10,470		

COTTON IN BRAZIL.²

The consensus of the early historians of Brazil is that cotton is indigenous to that country, and that while the natives probably did not

¹ See also article on culture of cotton.

² The principal authority upon which this account rests is Branner, Cotton in the Empire of Brazil, U. S. Dept. Agr., Special Report No. 8, 1885.

plant it they made use of the fruit of the wild plant to supply their few and simple needs for clothing and other textile products.

Beauchamp,¹ treating of the period immediately following the discovery (1500 to 1521), refers to cotton cords used by the Indians of Brazil upon their bows and for other purposes. Visconde de Porto Seguro,² in describing the customs and utensils of the ancient inhabitants of the Upper Amazon Valley, says: "They made use of blowguns, the arrows of which were wrapped with cotton." Auguste de Saint-Hilaire,³ one of the most trustworthy authorities and careful observers who have traveled in Brazil, says that the earliest travelers found cotton in use among Indians along the Brazilian coast; that they used it for making cords, hammocks, and even clothing, giving as one authority for this statement Hans Stade, who was held in captivity in southeastern Brazil from 1547 to 1555. Abundant evidence of the fact that cotton was used by the Indians at the time of the discovery of the country is furnished by the oldest documents upon Brazil referring to that event, and by the letters of the Jesuit missionaries who immediately undertook to Christianize the Indians. Also the existence among the aborigines of words signifying cotton points to their knowledge of cotton, and very probably to some of its uses. Nearly all of these words appear to be the same, or at least have the same origin. The slight differences that exist are probably caused by the differences in the dialects spoken by the various tribes of the Indians, or may be attributable to the differences among the observers and the different nationalities of the observers. One remarkable thing about these terms is that none of them bear any resemblance to the European words for cotton.

Gabriel Soares de Souza, who lived in what is now the province of Bahia from 1570 to 1587, describes in detail some of the Indians then inhabiting that part of Brazil. "It is customary for the men," he says,⁴ "to wear their hair so long that it reaches their waist, and sometimes they have it braided and intertwined with strips of cotton, so that it looks like a broad braid. The women are close shaven and wear about themselves aprons made of cotton thread, with a long fringe."

Claude d'Abbeville, a Capuchin missionary in Maranhao from 1612 to 1614, also reports the natives of that country as using cotton hammocks. In another place he says:⁵

They gather, clean, beat, and spin cotton with much dexterity, and with it make open hammocks resembling nets, and others as well woven and full of figures as if they were the work of better weavers; also aprons in which they carry their children about their necks.

¹ *Histoire du Brésil*, Vol. I, pp. 93, 96.

² *Historia Geral do Brazil*, Vol. I, p. 30.

³ *Voyage dans le District des Diamans*, pp. 253, 254.

⁴ *Revista do Instituto Historico do Brazil*, p. 352.

⁵ *Historia do Maranhao*, p. 356.

In 1570 to 1587 De Souza wrote of the cotton plant in Bahia: "These cotton plants are cleaned with the hoe two or three times during the year to keep the weeds from choking them."

Notwithstanding the general cultivation of cotton throughout Brazil, there is no record of its having been exported to any great extent, and but little evidence of its being exported at all, until the middle of the seventeenth century.

Marques¹ says that after the formation of the commercial company of Maranhao and Gram-Para the first exportation of cotton took place in 1760, which consisted of 651 arrobas, or 20,834 pounds. Camara says, in a memorial upon the cultivation of cotton published in 1749 in Lisbon, that cotton was first sent from Pernambuco to Portugal in 1778, and that up to 1781 the quantity shipped was very small.

J. B. Lyman² says that the export of cotton from Brazil to England began in 1781.

A commission³ appointed by the Government in 1852 to revise the tariff made the following report regarding the early exportation of cotton:

In some parts of Brazil in remote times there was no exportation of cotton—the cultivation was limited to what was necessary for use in that country. It was from Parahyba that it was first exported, whence it was sent to Portugal. Pernambuco was given up for a long time to the production of sugar, and it was only in 1778 that it exported this article for the first time. Its exportation, however, was very small until 1781.

Some side light is thrown on this subject in the story of the shipwreck of Jorge de Albuquerque Coelho.⁴ His vessel left Pernambuco on the 16th of May, 1565. On account of the condition of the vessel, they put back to port, and left again on the 29th of June, 1565. Their passage was a stormy one, and the sea became so rough at one time that they were obliged to throw over part of their cargo. The following is an extract from their report: "And seeing that all this was of no avail, and the winds grew higher, as if they wished to overwhelm us, we threw overboard the artillery, many boxes of sugar, and many bales of cotton." Now, this vessel was loaded in the province of Pernambuco, and the many boxes of sugar and bales of cotton must have been grown by the Portuguese within this province.

By the end of the seventeenth century the cultivation of cotton had become general throughout almost the whole of Brazil, and considerable quantities were being exported to Europe. During the eighteenth century the more general use of gold as a circulating medium, the removal of prohibitory laws, and the increased demand for raw

¹Marques, Dictionary of the Province of Maranhao, p. 13.

²J. B. Lyman, Cotton Culture, p. 153.

³Relatorio da Commissão da Revisão da Tarifa ao Governo Imperial, 1853.

⁴Revista do Instituto Historico do Brazil, p. 279 et seq.

material in Europe led to what was for those times an extensive cultivation and exportation.

The only statistics to be obtained up to the end of the eighteenth century are those of the province of Maranhao. From these we find that in 1800 5,529,408 pounds were exported, but this port stood only second among the cotton-exporting ports. Pernambuco probably exported twice as much, while Bahia, Rio de Janeiro, and Para together exported as much as Maranhao. Visconde de Porto Seguro says that 70,000 bags of cotton, 165 pounds to the bag, were exported, of which 40,000 were from Pernambuco, 16,000 from Maranhao, 10,000 from Bahia, and 4,000 from Para and Rio; and in another place he says that Ceara exported 40,000 sacks.

Upon the arrival of representatives of the royal family of Portugal (April, 1808) Brazil ceased to be a mere colony, and a new impetus was given to this as well as to the other industries. Ports were made free to friendly foreign powers, and the decree prohibiting the use of looms for other than the coarsest kinds of cotton was revoked. Cotton had now become a regular and constantly increasing article of exportation, being in such demand and commanding such prices that it was brought from great distances inland on the backs of mules and horses and over almost impassable roads.

Such was the condition of the cotton industry in Brazil at the time the United States entered the market as a cotton producer, and the effect of her rivalry in one of the most important branches of agriculture was very disastrous to cotton production in Brazil.

The territory of Brazil capable of yielding cotton is coextensive with the Empire itself. Cotton grows in almost every one of the provinces, and in regard to the others there exists little doubt of its adaptability to this plant.

Various authors mention cotton as grown on the Tapajos and the Madeira rivers. From Sao Paulo all along the coast to the Amazon, and for that matter throughout the whole Empire, cotton may be grown in almost unlimited quantities. In reality, however, its cultivation to a considerable extent is limited to the drier regions of the north, along the valley of the River Sao Francisco, and in some parts of the province of Minas Geraes. In the north—that is, to the north of Sergipe—a belt about 50 miles wide along the coast is for the most part devoted to sugar. Immediately beyond this is the region in which cotton is actually grown. The width of this cotton belt is restricted by inadequate transportation facilities. Transportation is principally on the backs of horses, and the railways are as yet too few to influence the amount of cotton produced.

As a rule, it may be said that the cotton belt in the north begins at the edge of the sugar belt, 50 miles inland, and extends about 200 miles inland, more or less, to the south; as it approaches the province of Bahia it extends inland, and keeps mainly within the region drained

by the Rio Sao Francisco. In the more southern provinces, from Espirito Santo and Rio de Janeiro, the amount of cotton produced at present for exportation is insignificant. Formerly, especially during the prevalence of the high prices caused by the civil war in the United States, cotton was grown in some of these southern provinces for exportation, especially Rio de Janeiro and Sao Paulo.

The island of Fernando de Noronha is an exception to the statement that the cotton is all grown inland. During the civil war in the United States and for some time afterwards the finest cotton sent from any part of Brazil was grown on this island, and was comparable with the Sea Island cotton, possibly fully its equal. But though efforts are being made to renew the cotton culture on the island, which went into decline in 1870 or thereabouts, the success has not been very great. The soil is remarkably fertile and the island is one of the best cultivated pieces of soil in Brazil.

It must not be supposed that only native species are grown, or, indeed, that any of the kinds commonly cultivated are native, though it is possible that one of the species supposed by some authors to be exotic is indigenous to South America. Planters seem to know of but three kinds, and even in these the differences are not always persistent. As a rule, the varieties are larger than ordinary cotton, and some of them are perennial.

None of these varieties of cotton produce more than one crop per annum, many assertions to the contrary notwithstanding. The even temperature throughout the year and the favorable weather lengthen out the picking time to several weeks and even months, and it is possible that those who state that there are two or more crops in a year mistake the various pickings for successive crops.

Sea Island cotton has been introduced in Brazil, but without success. The complaint that Brazilian cotton is dirty is not due to any quality of the cotton, but, like the Indian cotton, to the manner in which it is picked, cleaned, and handled.

In the Roteiro do Brazil a writer puts in a few words the process of cultivation in use in Bahia in its early history, and probably in all Brazil, as follows:

These cotton trees last seven and eight years and more if the ends of the large branches are broken off (for they dry up), in order that they put forth other new and more vigorous ones. These cotton plants are cleared with the hoe two or three times a year to keep the grass from crowding them.

In the preparation of the soil "all the planter has to do is to burn off the woods and plant his seed at the proper season." This is the whole story. There is no uprooting of stumps, no picking out of sprouts, no breaking up with a plow, no preparation of soil, no laying out of furrow, no cultivation other than the occasional chopping out with the hoe of weeds or sprouts. Therefore it is evident that the cultivation of cotton is almost without labor; in fact, Auguste de Saint-Hilaire says:

"Nothing in this country is less expensive or more productive than cotton culture."

In some sections the saw gin is used, though it has been found by experience to injure greatly the fiber of the Brazilian staple, and the common hand-roller gin is more frequently used. In connection with the gins there are rude presses, where the cotton is made into bales of about 385 pounds. A hand screw is the power used in this baling machine. Generally the seed are not turned to account. In a few instances, near the seaport, they have been shipped to England, or where steam engines are used for baling or ginning they are sometimes used as fuel. The greater part, however, is left to rot upon the ground or to be eaten by the cattle in the neighborhood. Only occasionally are they used as manure.

The home consumption of cotton is very large and is increasing. This is because of the difficulty of getting the raw material to market from remote points, the evenness of the temperature, which does not require warm clothing, and the high tariff upon foreign manufactured goods. Much of this manufacturing is done in the homes of planters, there being comparatively few manufacturing establishments in the country.

These establishments are mostly in the provinces of Rio de Janeiro, Minas Geraes, Sao Paulo, and Bahia, where the demands for ordinary grades of coarse cotton cloth are greatest, but they by no means have done away with domestic consumption of the raw material. There is no more familiar sight to the traveler in the interior of Brazil than that of spinning with the ancient distaff and spindle. Brazil undoubtedly weaves many thousand pounds of her cotton annually in that way.

The amount of cotton produced in Brazil in 1859-60 was 70,000 bales; in 1893-94, 300,000 bales. The amount manufactured in 1859-60 was 10,000 bales; in 1893-94, 100,000 bales.

Brazil exports about 150,000 bales of 400 pounds each to Europe, most of which goes directly to England; and should there be a demand sufficient to justify the planters to increase their acreage, the crop could be increased many-fold—in fact, there is sufficient good and available land to produce 40,000,000 bales, at a yield of only 100 pounds of lint per acre. As population increases and railroads are extended the cotton crop of Brazil may be expected to increase commensurately.

COTTON IN RUSSIA.

The Russian cotton-raising district lies in her Asiatic territory, in Turkestan and Transcaucasia. Russian Turkestan is bounded on the west by the Caspian Sea, Ural River and Mountains, on the east by the Pamir Plateau, Tian-Shan and Altai ranges, on the north by the Kirghiz steppes, and on the south by Afghanistan and Persia. Western Turkestan is commonly supposed to consist of vast low-lying sandy plains, but nothing could be more opposed to the actual conditions, for

the relief of the land here presents greater contrasts than are elsewhere found on the surface of the globe.

The lowlands bordering the Caspian Sea are sometimes as much as 80 feet below the sea level, while the highlands of the Tian-Shan peaks rise 25,000 feet above the sea. The Aralo-Caspian basin is watered by the rivers Amu-Daria, Zerafshan, Murghab, and Syr-Daria.

The low-lying and level parts of Turkestan are covered with marine and lacustrine deposits of geological epochs preceding the present one. Here are found conglomerates, sands, and porous or loose soils. These recent deposits are well adapted for cotton growing.

In this district cotton has been cultivated from most ancient times. In all probability this culture began at the time when the Asiatic cotton plant (*Gossypium herbaceum*) began to develop on the borders of the Oxus (Amu-Daria) and Seikhoun (Syr-Daria), to which it had been brought from southern Asia. After the plant became acclimated in that northern latitude several new varieties were produced, and its cultivation contributed much to the welfare of the inhabitants, who produced sufficient for their own use and exported some to neighboring countries. During this time there were no planters who devoted themselves entirely to the cultivation of cotton. It was grown on lands unoccupied by such prime necessities of life as wheat, rice, barley, and other staples.

Such was the state of cotton growing in Turkestan before the Russians entered that territory. The quantity produced fluctuated according to the prices and demands from other countries, Russia being the largest customer. Cotton cultivation attained its greatest development soon after 1860, when the Russian cotton trade, together with that of other European nations, was undergoing a severe crisis in consequence of the great decrease of fiber from the United States. The prices being very high at that time, its production increased in the Bokhara, Khiva, and Khanstvo districts, and also in the Transcaucasian districts, to such degree that the crisis passed more or less fortunately. After the Russians had thoroughly conquered Turkestan the quantity of cotton grown in that province decreased very rapidly, chiefly on account of the decline in prices. Russia, however, soon found the value of this product to her textile industries and began to devote a great deal of attention to the development of the plant. As it was of great importance, not only to the province itself, but also to Russia, which had been obliged to buy all raw cotton from the United States and Egypt, the Government gave the culture every encouragement.

As in all other cotton-raising countries, an effort was made to introduce the American cotton into Turkestan, but all attempts to cultivate the imported seed were for ten years very unsuccessful, mainly because Sea Island was most frequently planted and the dry weather of Turkestan was unsuitable to this variety. In 1880 it was discovered that upland cotton could be successfully grown there, and energetic

measures were taken for its introduction and cultivation. The Government established a cotton plantation at Tashkend, manuals for the cultivation of the American upland cotton were published in the Russian and local languages, seeds were distributed free of cost to those who desired them, and the sale of the cotton fiber raised from the imported American seed was guaranteed.

Methods of ginning and cleaning the cotton were also improved, gins being ordered from the United States, with the result that cotton fiber of the American variety grown in Turkestan had a great influence on the Russian market and its price was much better than that of Asiatic varieties. The construction of the Transcaspian railway also had an important bearing on the increase of cotton growing in this country, and the area under crop increased from 810 acres in 1884 to 120,150 acres in 1889. In 1890 there were 245,000 acres planted in cotton in Turkestan, from which more than 45,600,000 pounds of clean fiber were collected, an average yield of 186 pounds per acre.

Of the three districts—Syr-Daria, Fergana, and Samarkand—in which most of this cotton is raised, Fergana is much the largest producer. While the production of cotton in Turkestan will in all probability increase still further, it must be borne in mind that the increase is limited by the extent of the artificially irrigated lands suited to cotton growing; yet within this limit, by the rational employment of the water supplies, especially those of the Syr-Daria, and the construction of new irrigation systems, the quality of the crop may be improved and the quantity largely increased.

The methods of cultivation of the cotton plant in this region are exceedingly varied and have not been definitely fixed. The more intelligent growers are still experimenting and seeking new methods. Different systems of plowing and preparation of the soil, of sowing and irrigating, are being adopted in the hope of thus obtaining better results. Yet, on the whole, the methods of cultivation have changed comparatively little and are being very slowly perfected. The preparation of the fields with improved implements, the manuring of the soil, and the careful selection of seed are only found on the few Russian growers' plantations around Tashkend, and still more rarely in the territories of Fergana and Samarkand. "The local planter breaks up the soil with the aid of a primitive wooden plow known as the 'sokha' (a turn plow is unknown), harrows the field with a single board, covers the seed by hand, applies manure only in exceptional cases, and pays no attention to the choice of seed, which he sows broadcast"—in fact, makes use of the methods inherited from past generations of ignorant cotton raisers—yet, thanks to the exceedingly favorable conditions of soil and climate, generally harvests a good crop.

Most of the plantations are small, those of over 270 acres being exceptions. These belong to Russian planters and trading firms. The large majority of the holdings consist of plats of from 1 to 15 acres and

are cultivated by the natives, yet these small cultivators supply at least 90 per cent of the total production.

The average crop of upland cotton in the Syr-Daria territory can be taken as 25 pounds of pure fiber per acre, while that of the local variety is about 180 pounds. In the Fergana and Samarkand territories the average yields from the same area are 250 pounds of upland and 190 pounds of local. Of course, in some cases, particularly when the autumn is warm and free from frost, considerably heavier crops are secured. There are instances of yields of 450 pounds of pure upland and 360 pounds native cotton per acre.

Almost all the native cotton is still cleaned by wooden machines worked by hand power, which while not rapid are very cheap. Nearly all the upland cotton is sent to special cleaning mills, where improved gins, generally worked by water power, though sometimes by animal power and less frequently by steam, are to be found. These gins are mainly in the towns which serve as centers of the cotton-growing districts, but a few are to be found in the larger settlements around which are extensive plantations.

In 1893 there were about 100 mills in all Turkestan, in which more than 400 gins and 120 presses were at work. Most of these gins were imported from the United States, but there were also Russian-made gins.

The seed is used for planting, for the production of oil, and for fuel. The cake left over from the oil press is utilized as cattle food. The lint is pressed into bales of from 250 to 325 pounds, which are then dispatched to Samarkand, the terminus of the Transcaspian railway, upon the backs of camels or in a rude cart known as the "arba." The camel load is 2 bales, or 500 pounds, and an arba load 6 bales, or 1,500 pounds. The almost impassable condition of some of the roads makes the transportation of cotton very slow, and a periodical delivery at the railroad station is not yet to be thought of, but when new lines of railway which have been projected into the cotton-growing districts are finished, especially that from Samarkand to Kokand, penetrating the Fergana territory, transportation will be improved and the cost of delivery to the railway, and consequently to European Russia, will be cheapened, thus increasing the demand and inducing larger plantings.

Cotton for European Russia is shipped from other countries of central Asia, namely, Bokhara, Khiva, and the Transcaspian territory. Bokhara produces about 54,000,000 pounds of cotton, mostly of the Asiatic variety. This cotton is shipped by the Transcaspian line of railway. Khiva produces about 21,000,000 pounds, almost exclusively a native variety, but considerably superior in its quality to the other Asiatic growths. The larger portion of this cotton enters Russia through Orenburg by camel caravans; the rest is dispatched by boats by the way of the Amu-Daria to a station of that name on the Transcaspian railway, and thence by rail.

The Transcaspian territory produces but 360,000 pounds of cotton, mainly the upland variety, and most of that in the neighborhood of Merv. Thus all the central Asiatic countries together produce 144,000,000 pounds of cotton, more than three-fourths of which is sent to European Russia.

Another considerable district of cotton culture in the Russian Dominion is Transcaucasia, where upland cotton has made little progress in displacing the variety cultivated by the natives from very early times. There are about 100,000 acres devoted to cotton in Transcaucasia, the greater part of which is in the Erivan government. The total production in 1891 was about 22,000,000 pounds, the average crop being 230 pounds per acre of upland, the local plant not yielding quite so much. The methods of cultivation are being perfected and the quantity of cotton produced is increasing.

It may be said in general that the raising of American cotton has been making considerable progress in Russia and Turkestan. In the year 1892 1,080 acres were planted with American cotton in the district of Dshisak, Province of Samarkand, producing a crop of 783,000 pounds of raw cotton, from which 234,000 pounds of clean cotton was obtained—that is, 216 pounds per acre on the average. Reports of a later date are not available.

Experiments on methods of culture and test of varieties are still being carried on in this region under the supervision of the Russian Government. The American upland variety known as Ozier Silk is generally grown. Sea Island cotton will not mature in this region which is near the northern limit of successful cotton culture, but it has been found that with upland varieties the season is shorter and harvesting is usually finished by the time that it begins in the southern United States. The quality of the fiber is apparently fully equal to that of the American product from the same varieties. These results are not surprising for it is a well-known fact that “nowhere are plants cultivated so advantageously, whether from the point of view of quality and quantity or that of cheapness of production, as at the northern limits of their sphere of cultivation.”

In the whole Province of Samarkand there are 8 cotton gins; there were in 1890 5,764 acres planted with American cotton and 15,762 acres with domestic cotton; in 1892 the proportion was reversed, there being 12,204 acres devoted to American cotton and 3,510 acres to domestic cotton.

In the Province of Khojend American cotton is rapidly taking the lead, and the cotton acreage is also increasing; in 1892 there were produced 3,780,000 pounds, which equaled 244 pounds of cleaned cotton to the acre on a general average.

A steady progress of cotton culture would appear from the statement that the quantities of cotton carried by the Transcaspian railroad to the Russian market have increased from 31,428,000 pounds in 1888 to 129,168,000 pounds in 1893, and that of the whole bulk of cotton

shipped in 1894 72,000,000 pounds was American cotton, while in 1884 there were only 250,000 pounds of that variety raised.

It is said that the plant deteriorates in Turkestan and can only be kept up to its high standard by frequent renewal of American seed.

Notwithstanding the large production of cotton in this portion of the Russian Empire and the fairly rapid development and increase of the crop, the time is probably still far distant when Russian cotton mills will manufacture exclusively Russian-raised cotton. The supply of cotton from central Asia in the Russian markets, though largely increased of late, is still far from being sufficient to satisfy the continually increasing demand, and the quantity of cotton imported is diminishing but slowly. The amount of cotton brought into Russia from abroad in 1891 was 351,939,412 pounds, the average for the ten years preceding being 290,000,000 pounds. The greatest quantity of cotton used in Russia comes via the European frontier from the United States, Great Britain, Germany, and Egypt. Great Britain and Germany send American, Brazilian, Indian, and perhaps also Egyptian cotton. In 1891 Russia imported from the United States 136,749,492 pounds, from Great Britain 23,597,820 pounds, from Egypt 64,749,492 pounds, and from Germany 24,347,736 pounds, and used about 108,000,000 pounds (nearly one-third of the total consumption) of the product of her Asiatic dominions. The entire consumption of cotton in European Russia appears to have been 500,000,000 pounds in 1892 and about 70,000,000 less in 1893. It is possible that the construction of railroads into the cotton-growing regions and improvements in methods of culture will ultimately result in a balance between Russian exports and imports of cotton.

This view appears to have some confirmation from the figures of the cotton trade of the United States with Russia. During the four years 1881-1884 the United States exported annually an average of 124,117,441 pounds of cotton to Russia. In the period 1885-1888 the average was 86,014,804 pounds, and it fell to 75,889,614 pounds in the period of 1889-1892. The decline was from 134,000,000 pounds in 1881 to 67,000,000 pounds in 1892, a fall of 50 per cent. Thus, while there is probably no immediate prospect of Russia producing all the cotton she needs, our own declining trade gives some warrant for apprehension that in the future our cotton planters will meet a competition from this source.

COTTON IN JAPAN.

Cotton (lint, *wata*; plant, *ka-wata*) is cultivated to a considerable extent in Japan, where it was introduced from India many years prior to its introduction into China. It has ordinarily been said that the introduction of cotton was from China in the sixteenth century, while in fact the cotton plant was cultivated to a limited extent in Japan several hundred years previous to that date. Fesca¹ says that cotton

¹Japanischen Landwirthschaft, 1893, Pt. II, p. 485.

was first accidentally introduced into Japan in the year 781 A. D. from India, and that its culture soon ceased; that again, several centuries later—probably 1592—it was introduced by the Portuguese, though this is not positively authenticated. However, it was in the seventeenth century, during the reign of Tokugawa, that the spread of cotton culture in Japan began, which has continued until the present time.

According to a paper by Poate read before the Asiatic Society of Japan in 1876, one of the old and sacred books of Japan, called Wajishi, contains an account of the introduction of cotton into that country which supports the above statement.

The cleaning of the cotton is largely done with the scutch, or bow, and the roller gin, or chureka, is in common use. The lint is ordinarily packed in 100-pound bales.

The quality of the Japanese cotton—at least that produced in the best cotton districts—is good, though the staple is considerably shorter than the ordinary tree or shrub cotton. The staple is seldom more than 1.8 centimeters in length. The best cotton is also elastic and glossy, but the gloss appears to be more a result of climate and locality than of variety, a damp climate being unfavorable to the production of glossy fiber. The cotton of the damp San-in-do region has little gloss, while that of the neighboring province, especially that of the Osaka Fu and Wakayama Ken, possesses a very good gloss. The last-named lint is considered the best. It is of medium length, soft, very elastic, and glossy as silk. The strength of the lint in the province of Suo is well known. That produced in the San-in-do district is mostly short staple, hard, and without gloss, probably on account of the low temperature and humidity of the climate. In the provinces of Kuantoebene and Hitachi, and on the north edge of the cotton region, there is produced a long and fine staple cotton which is quite elastic and strong. The relation of lint to seed is very favorable. Generally it stands 60 per cent seed and 40 per cent lint. The cotton of Kuantoebene is an exception to this, being only between 20 and 30 per cent lint.¹

Statistics of the total product of the Empire are to be had for the years 1878–1884, 1887, 1891 in unginned cotton and are as follows:

*Total production of unginned cotton in Japan.*²

Year.	Pounds.	Year.	Pounds.
1878.....	118,958,541	1883.....	139,510,675
1879.....	207,888,208	1884.....	127,493,691
1880.....	118,685,333	1887.....	186,571,583
1881.....	120,678,880	1891.....	109,839,383
1882.....	115,162,850		

The acreage under cotton, while not in itself large, is in fact much larger than that devoted to any other textile fabric, and in 1887 was 2

¹ *Japanischen Landwirthschaft*, 1893, Pt. II, pp. 474, 475.

² The present production of ginned cotton is given as about 75,000 bales (of 400 pounds) by Shepperson.

per cent of the entire cultivated area. In west Japan, which produced large quantities of cotton, the cotton fields occupy 4.8 per cent of the entire arable land, against 2.77 per cent in middle Japan, 1.45 per cent in Shikoku, 0.45 per cent in Kiushiu, and 0.34 per cent in north Japan. West Japan furnishes nearly half of the total production, 49.48 per cent; middle Japan, 40.67 per cent, although the cotton area of west Japan is only 80 per cent of that of middle Japan.

During 1891 the amount of cotton raised was 109,000,000 pounds, and in 1892 Japan imported 100,000,000 pounds of raw cotton, of which not more than one-tenth came from the United States, two-fifths from China, and one-half from all the other countries; and her exports amounted to 325,000 pounds of raw cotton, of which 300,000 pounds went to Korea, leaving for home consumption somewhat over 208,000,000 pounds. During the years 1891 and 1892 the average value of Japanese coins varied so much that though the total value of trade for 1892 exceeded that of the previous year by 19,974,000 yens, yet when reduced to United States money at the rate of exchange for that year the increase was only \$761,000, making it difficult to satisfactorily compare amounts with previous years. The most important thing concerning the foreign trade of Japan is the increasing facilities of the country for manufacturing her own supply. Especially is this noticeable in relation to cotton goods. New spinning mills are being established from time to time, and large profits are made from those already at work. The consumption of cotton goods is increasing each year, and home factories are supplying a larger and larger percentage of the entire amount consumed. In 1892 Japan imported \$9,250,000 worth of textile fabrics, of which the larger portion was probably cotton, besides \$8,750,000 worth of raw cotton and \$5,000,000 worth of cotton threads and yarns.

COTTON IN CHINA AND KOREA.

CHINA.

The Chinese began to make extensive use of cotton fiber about 1300 A. D., and since that date the growth and manufacture of cotton has reached immense proportions in the Celestial Empire; but statistics of the cotton crop in that country are not attainable, the closest estimate being 1,600,000 bales of 400 pounds each as a product of China and its former dependency Korea at the present time. The great cotton region of China lies along and on both sides of the river Yang-tze-Kiang, where the soil is very fertile, perhaps surpassing any other district of China.

The method of cultivation is very primitive. In some cases the ground is plowed in March, or as soon as the frost is out of the ground, and the seed is sown broadcast. Under this system of cultivation the plants grow very thickly, almost as close as cereals; they are spindling and short and the bolls are small. The yield per acre varies from 50 pounds to 1,000 pounds of unginned cotton. The method of cultivation varies, however, in different parts of China, for in other cases after

plowing the seed is planted in hills on ridges and cultivated with the hoe.

About five months after planting picking commences, this being the work of women and children; after the crop is gathered the stalks are pulled up and preserved for fuel.

There are no large cotton plantations in China, most of the cotton being raised on patches varying in size from a few square yards to one or two acres. The old Hindoo churchka is generally used for ginning, the scutch or bow for cleaning, and the spindle and handloom for manufacturing, but cotton factories are being established in some localities. The quantity consumed can not be determined from any statistics kept at the open ports. The farmers do not usually sell their cotton, but it is spun and woven by the women, and any surplus cloth is sold in the neighborhood. They make use of the seed for the extraction of oil, and use the oil for illuminating purposes. China exports some cotton to Japan, but the imports of yarn and cloth from Japan, India, and England are far in excess of the exportation of raw cotton.

KOREA.

Though the books of the treasury of Korea show only 190,000 acres devoted to cotton culture, it is probable that owing to the system of taxation the estimate is not more than one-fourth of what it should be, and that the total acreage is about 800,000 acres. On this is produced annually about 800,000,000 pounds of unginned cotton. It is cleaned by hand machines and yields about 200,000,000 pounds of lint, or about 250 pounds per acre. Most of this is consumed at home, giving about $13\frac{1}{3}$ pounds for each person. It is grown chiefly in the provinces of Huang-Hai, Chel-La, and Kyeng-Sang, and to some extent in Chung-Cheng and Kyeng-Kwi. Because of lack of information on Korean affairs, it is quite impossible to say how much of the land is suitable for cotton, but it may be said that the area under culture is practically dependent upon the price of the fiber. Probably one-half of the tillable land might be so cultivated, although only a small portion is now used.

Cotton was brought to Korea about 500 years ago from China. The soil and climate have improved the original plant, giving it a longer staple and finer fiber. It is the perennial variety, but it is found more profitable to uproot it and replant each year. The stalk is used for fuel and its ashes for manure. Chinese usages are closely followed. Korean cotton fiber is considerably better than that of China or Japan in durability and warmth-retaining qualities. Cloth is all made in private families and for private use, but no statistics can be obtained.

COTTON IN OTHER COUNTRIES.

At least nine-tenths of the world's supply of cotton is produced by the countries already referred to, but there are several other countries which either already produce small quantities of cotton or might enter

the list of cotton-producing countries. They have climate and soil suitable to the growth of this plant, but are prevented at present from entering this industry upon any extended scale either because of scanty population, difficulty of transportation, or greater profit gained from the cultivation of other crops. The total amount produced by these countries as a whole in 1893 is estimated at about 130,000 bales.

MEXICO.

Of these, Mexico, by reason of its proximity to the United States, is probably for us the most important. It has been estimated by Ruiz that the annual production of cotton in Mexico prior to the conquest by Cortez was about 116,000,000 pounds, but under the rule of the Spaniards the cultivation declined until it was entirely abandoned in many sections of the country. Some new impulse was felt about 1860, at which time every country that could produce cotton was called upon to attempt to make good the decrease of receipts by European countries from the United States. Since 1882 a larger interest has developed in Mexico in the culture of cotton, so that every State suitable for its culture has more or less area devoted to the plant. Ruiz, in his report on "Cotton in Mexico," estimated that in 1892 the output equaled 25,000,000 pounds of ginned cotton.

The greater part of the Mexican crop is produced in the State of Coahuila, but there are three well-defined cotton sections in Mexico—one along the eastern coast, one in the central plateau, and the other on the west coast, of which the inland section is the largest producer. The crop there, however, is dependent upon the water available for irrigation. Biaconi¹ gives it as his opinion that if all the land suitable for the purpose were put under cultivation the Mexican Republic might easily become a rival of the United States in the production of cotton. As the conditions now are, Mexico is obliged to purchase cotton for its own needs from the United States. The best cotton is produced in the State of Guerrero in the neighborhood of Acapulco, and the most inferior is produced in the State of Chiapas. In the zone along the Gulf of Mexico, 300 miles long by about 50 miles wide, cotton could be raised, but a lack of labor is a great drawback to this enterprise. Besides, coffee growing offers so much greater profit that few agriculturists give serious thought to the growing of cotton. On the Pacific Slope the cultivation of cotton comprises the whole coast, where there is much land that exhibits great fertility; on account of the cost of transportation and lack of railway facilities, however, the extension of cotton culture has been retarded. Although in the interior of the country there exists no continuous stretch of land especially favorable to the culture of cotton, there are, nevertheless, centers which are capable of becoming large producers of the staple. The State of Coahuila is situated in this section, and Laguna is the most important of the cotton-

¹ "Le Mexico."

growing districts of the State, as it produces at least one-half the cotton raised in Mexico. It is about 360 miles southwest from Eagle Pass, Tex., and is skirted by the Mexican International and Mexican Central railways, being therefore provided with an outlet for its cotton crop.

Cotton manufacturing—at least as the term is understood in these modern days—has received an impulse only within the last few years, but is extending itself so that there is hardly a State that has not an establishment for spinning and weaving cotton, and these factories not only consume the entire home product, but also from 50,000 to 70,000 bales of cotton from the United States, the amount increasing as the shortage in the home-raised crop necessitates larger imports from abroad.

PERU.

Cotton is indigenous to Peru, or at least it has grown there from prehistoric times.¹ The inhabitants at the time of the conquest by the Spanish troops were clothed in cotton, and mummies of very ancient date have been found wrapped in cloths or blankets wholly or in part composed of cotton, but, as was the case in Mexico, the culture of cotton was much neglected by the Spanish conquerors, whose eager search for precious metal led them to ignore the greater agricultural wealth of their colonies. Statistics as to the output of cotton in Peru are not available, nor are the exports of cotton to other countries to be had for dates earlier than 1862, when 341,243 pounds were exported to Liverpool. In 1865 the exports had increased to 4,145,260 pounds. From 1885 to 1892 the average export of cotton from Peru to Liverpool was about 6,000,000 pounds, to which must be added the amounts shipped to New York. The variety *Gossypium barbadense peruvianum*, with a rough, strong fiber, is cultivated along the banks of rivers and lowlands irrigated by the overflowing streams. It is perennial, and when conditions are favorable will bear two crops a year for many years, but the ordinary productive stage is about seven years. The rainy season ends about the middle of April, and the first crop is gathered in February. The second crop is probably the largest of the series, with a gradual diminution with each successive crop until the yield is no longer remunerative. The chief use of this cotton, which is known as "Rough Peruvian" in commerce, is for mixing with wool. It lessens the tendency of the goods in which it is used to shrink, makes them more durable, and gives a better luster and finish; hence it is frequently used in the manufacture of underwear and hosiery. This peculiarity of the Peruvian cotton is probably the result of soil and climate, and its cultivation is therefore likely to be restricted to that country. It would be very difficult to find a section in the United States that would furnish a uniform and high heat during the ten months necessary for the development of the plant, or the other conditions which contribute to the successful cultivation of this cotton.

¹Auxiliador da Industria Nacional, 1878, p. 90.

The imports into the United States¹ for each calendar year since 1885 have been as follows:

Imports of Peruvian cotton into the United States.

Year.	Bales.	Year.	Bales.
1885.....	14	1891.....	10,515
1886.....	843	1892.....	13,000
1887.....	2,493	1893.....	24,000
1888.....	4,279	1894.....	19,000
1889.....	7,650	1895.....	24,000
1890.....	9,500		

AFRICA.

Excluding Egypt, which has been treated in another place, the continent of Africa produces a considerable amount of cotton on both the eastern and western coasts, as well as in the central part; in fact, the whole population is clothed in cotton, the greater part of which is home grown and manufactured. Cotton is indigenous to Senegambia, Liberia, the Congo States, and Soudan, and under proper cultivation these districts are capable of producing more cotton than is now raised in the United States, but such a condition of things is too remote a possibility to awaken any interest among cotton raisers or manufacturers at the present time, and only mentioned to indicate a section where cotton might be abundantly and cheaply produced.

EAST INDIES.

Cotton is cultivated in all parts of Java, the estimated amount being about 6,500 bales of 400 pounds each, one-half of which is used in Java for stuffing mattresses, cushions, etc. Some cotton is also grown in the Siam Malay States and is manufactured by the very primitive homemade machines into a cloth very durable, but not as attractive as the cotton cloths of Europe, which are largely superseding the domestic product among the natives. There has been some exportation of cotton from the East Indies to the continent of Europe, but the amount is comparatively insignificant.

WEST INDIES.

The West Indies produced cotton long before it was cultivated in the cotton belt of the United States. For a while the total American supply to Europe came from these islands. In 1801 25,000 bales were exported; in 1836, 20,000 bales; and since that date the crop exported has steadily decreased until scarcely a thousand bales are credited to these islands. This decrease is largely due to a greater profit coming from the cultivation of other crops, and there is no prospect as long as the present conditions exist for an increase of the cotton crop in the West Indies.

¹ Cotton Facts, December, 1895.

THE LEVANT.

Under this name the cotton raised in Greece and Turkey and her provinces is known in the European market. The total amount is small, probably not more than 20,000 bales of 400 pounds each, 25 per cent of which is used in the countries where produced, the remaining 75 per cent being shipped to England and the continent of Europe. It is safe to say that the acreage under cotton culture in this district is decreasing annually. Some of the staple is long, white, and equal to good American cotton.

SOUTH SEA ISLANDS.

Many of the islands of the South Sea or Southern Pacific produce some cotton of a good staple, but their output, considered as individual islands or as a combined section, is inconsiderable, having no appreciable effect upon the supply in the markets of the world.

Australia has also produced some cotton, and some sections of the country are very well adapted to the growth of the plant. Attempts have been made to extend its culture, but without success, owing probably to the sparse population and the comparatively small returns from the cultivation of the fiber.

BOTANY OF COTTON.

By WALTER H. EVANS, Ph. D.

Office of Experiment Stations.

The cotton plant belongs to the Malvaceæ, or the mallow family, and is known scientifically by the generic name *Gossypium*. It is indigenous principally to the islands and maritime regions of the tropics, but under cultivation its range has been extended to 40° or more on either side of the equator, or to the isothermal line of 60° F. In this country latitude 37° north about represents the limit of economic growth. The generic description as compiled from various sources is as follows:

Gossypium.—Herbaceous, shrubby or arborescent, perennial, but in cultivation herbaceous and annual or biennial, often hairy, with long, simple, or slightly branched hairs, or soft and tomentose, or hirsute, or all the pubescence short and stellate, rarely smooth throughout; stem, branches, petioles, peduncles, leaves, involucre, corolla, ovary, style, capsule, and sometimes the cotyledons more or less covered with small black spots or glands. Roots taprooted, branching, long, and penetrating the soil deeply. Stem erect, terete, with dark-colored, ash-red, or red bark and white wood, branching or spreading widely. Branches terete or somewhat angled, erect or spreading, or in cultivation sometimes very short. Leaves alternate, petioled, cordate or subcordate, 3 to 7 or rarely 9 lobed, occasionally some of the lower and upper ones entire, 3 to 7 veined. Veins branching and netted; the midvein and sometimes adjacent ones bear a gland one-third or less the distance from their bases, or glands may be wholly absent. Stipules in pairs, linear-lanceolate, acuminate, often caducous. Flowers pedunculate. Peduncles subangular or angular, often thickened toward the ends, short or very short, erect or spreading; in fruit sometimes pendulous, sometimes glandular, bearing a leafy involucre. Involucre 3-leaved, or in cultivation sometimes 4; bracteoles often large, cordate, erect, appressed or spreading at summit, sometimes coalescent at base or adnate to the calyx, dentate or laciniate, sometimes entire or nearly so, rarely linear. Calyx short, cup-shaped, truncate, shortly 5-dentate, or more or less 5-parted. Corolla hypogynous. Petals 5, often coalescent at base and by their claws adnate to the lower part of stamen tube, obovate, more or less unequally transversely dilated at summit, convolute in bud. Staminal column dilated at base, arched, surrounding the ovary, naked below, above narrowed and bearing the anthers. Filaments numerous, filiform, simple or branched, conspicuous, exerted. Anthers kidney-shaped, 1-celled, dehiscent by a semicircular opening into two valves. Ovary

sessile, simple, 3 to 5 celled. Ovules few or many, in two series. Style clavate, 3 to 5 parted; divisions, sometimes erect, sometimes twisted and adhering together, channeled, bearing the stigmas. Capsule more or less thickened, leathery, oval, ovate-acuminate, or subglobose, mucronate, loculicidally dehiscent by 3 to 5 valves. Seed numerous, subglobose, ovate or subovate, oblong or angular, densely covered with cotton or rarely glabrous. Fiber sometimes of two kinds, one short and closely adherent to the seed; the other longer, more or less silky, of single simple flattened cells more or less spirally twisted, more readily separable from the seed. Albumen thin, membranous, or none. Cotyledons plicate, auriculate at base, enveloping the straight radicle.

Embraced by this description as synonyms are *Sturtia* R. Brown and *Xylon* Tournefort, both of which are antedated by the name *Gossypium* of Linnæus.

On account of their great variability the species of this genus are difficult of limitation, and various attempts have been made to classify them. Linnæus described at least 3 species, and since that time the number of species and synonyms has increased enormously. Two monographs of the genus have been published by Italian botanists, the first by Filippo Parlatore¹ in 1866, in which the author recognized 7 species, with 8 others in doubt. The other monograph was by Agostino Todaro,² published in 1877, in which are described 52 species, with 2 as uncertain. Hamilton sought to avoid confusion by dividing the genus into 3 species, the white seeded, black seeded, and yellow linted, to which he gave the names *album*, *nigrum*, and *croceum*. A recent publication, *Index Kewensis*,³ recognizes 42 species, of which but a very few are of economic importance, and mentions 88 others that have been reduced to synonyms, most of them being synonyms of species in common cultivation. The great variability and the tendency to hybridize make it difficult to determine to which species a given plant may belong. No cultivated plant responds so quickly to ameliorated conditions of soil, climate, and cultivation as the cotton plant, and to this fact is due much of the confusion as to species and varieties. Another factor entering into the confusion is the imperfectly known types that have been described as species. It has been stated that some of the species now widely cultivated are wholly unknown in a wild state, and some of the specimens described by Linnæus were in all probability from plants that had long been in cultivation. The work of establishing the origin of the cultivated species has been still further complicated by the exchange of seed from country to country that has been going on for at least four centuries.

Among the species recognized to be of more or less economic importance are *G. arboreum*, *G. neglectum*, *G. brasiliense*, *G. herbaceum*, *G.*

¹ Le specie dei cotonei.

² Rel. sulla coltura dei cotonei in Italia, 1877-78.

³ Vol. 2, pp. 1057, 1058.

barbadense, and perhaps a few others. In this country only the herbaceous cottons are cultivated to any extent. The shrubby and arborescent are grown occasionally as curiosities, but they seldom or never produce any lint in regions having as low a mean temperature as the cotton belt of the United States.

The determination of the species of cotton grown in this country presents some peculiar difficulties. The authorities differ widely regarding the specific origin of the short-staple or upland cotton, while more



FIG. 1.—Sea Island cotton (from photograph furnished by Mississippi Experiment Station).

nearly agreeing on that of the Sea Island cotton. The latter is generally considered as having originated from *G. barbadense*, a technical description of which is given below.

G. barbadense Linn. was originally described as having leaves 3-lobed, entire. A more amplified compiled description is as follows: Shrubby, perennial, 6 to 8 feet high, but in cultivation herbaceous and annual or biennial, 3 to 4 feet high, glabrous, dotted with more or less prominent black glands. Stem erect, terete, branching. Branches graceful,

spreading, subpyramidal, somewhat angular, ascending, at length recurving. Leaves alternate, petiolate, as long as the petioles, rotund, ovate, subcordate, 3 to 5 lobed, sometimes with some of the lower and upper leaves entire, cordate, ovate, acuminate; lobes ovate, ovate-lanceolate, acute or acuminate, channeled above, sinus subrotund, above green, lighter on the veins, glabrous, beneath pale green and glabrous, 3 to 5 veined, the midvein and sometimes one or both pairs of lateral veins bearing a dark-green gland near their bases. Stipules erect or spreading, curved, lanceolate-acuminate, entire, or somewhat laciniate. Peduncles equal to or shorter than the petiole, erect, elongating after flowering, rather thick, angled, sometimes bearing a large oval gland below the involucre. Involucre 3-parted, erect, segments spreading at top, many-veined, broadly cordate-ovate, exceeding half the length of the corolla, 9 to 11 divided at top, divisions lanceolate, acuminate. Calyx much shorter than the involucre, bracts cup shaped, slightly 5-toothed or entire. Corolla longer than the bracts. Petals open, but not widely expanding after flowering, broadly obovate, obtuse, crenate or undulate margined, yellow or sulphur colored, with a purple spot on the claw, all becoming purplish in age.* Stamens about half the length of the corolla, the tube naked below, anther bearing above. Style equaling or exceeding the stamens, 3 to 5 parted. Ovary ovate, acute, glandular, 3, rarely 4 to 5 celled. Capsule a little longer than the persistent involucre, oval, acuminate, green, shining, 3, rarely 4 to 5 valved. Valves oblong or ovate-oblong, acuminate, the points widely spreading. Seed 6 to 9 in each cell, obovate, narrowed at base, black. Fiber white, 3 to 4 or more times the length of the seed, silky, easily separable from the seed. Cotyledons yellowish, glandular punctate.

Species which have been considered synonyms of *G. barbadense* and to which the above description will apply are *G. frutescens* Lasteyr., *G. fuscum* Roxb., *G. glabrum* Lam., *G. jamaicense* Macfad., *G. javanicum* Blume, *G. maritimum* Todaro, *G. nigrum* Hamilton, *G. oligospermum* Macfad., *G. perenne* Blanco, *G. peruvianum* Cav., *G. punctatum* Schum. and Thonn., *G. racemosum* Poir., *G. religiosum* Parlatore, *G. ritifolium* Roxb., and perhaps others.

This species is indigenous to the Lesser Antilles and probably to San Salvador, the Bahamas, Barbados, Guadaloupe, and other islands between 12° and 26° north latitude. By cultivation it has been extended throughout the West Indies, the maritime coast of the Southern States, Central America, Puerto Rico, Jamaica, etc., southern Spain, Algeria, the islands and coast of western tropical Africa, Egypt, Island of Bourbon, East Indies, Queensland, New South Wales, etc. It may be cultivated in any region adapted to the olive and near the sea, the principal requisite being a hot and humid atmosphere, but the results of acclimatization indicate that the humid atmosphere is not entirely necessary if irrigation be employed, as this species is undoubtedly grown

extensively in Egypt. As a rule, the quality of the staple increases with the proximity to the sea, but there are exceptions to this rule, as that grown on Jamaica and some other islands is of rather low grade, while the best fiber is produced along the shores of Georgia and Carolina. According to Royle¹ "the quality is influenced not only by temperature, but the balance between the amount of moisture taken up by the roots and that given off by the leaves must be considered, as well as the varied processes of culture and choice of varieties suited to each particular locality." This observation applies to all kinds of cotton, and not to the Sea Island alone. Some authors question the American origin of this species, and one, Maxwell T. Masters,² claims that it is of central African origin; but the weight of testimony is against him, and in all probability this was the species grown on the island of San Salvador at the time of the landing of Columbus and by him carried to Spain. Some authors claim to recognize a difference between *G. barbadense* and *G. maritimum*; but whether it is more than a cultural variation is very difficult to determine, and for our purpose they are considered as botanically synonymous, while they may be commercially different.

There is a well-marked form of the Sea Island cotton, to which Todaro gave the varietal name of *polycarpum* to which is usually referred the Bamia variety of Egyptian cotton. It is principally characterized by numerous flowers springing from a single axil, and an erect, slightly branching habit, hence giving a large yield per acre. On poor soil it soon degenerates to an ordinary form of Sea Island. This is considered by Sir J. D. Hooker³ as a well-marked seminal sport, with a fastigate habit, from some kind of Egyptian cotton, the bulk of which belongs to the Sea Island form of *G. barbadense*. In one of the Kew reports⁴ the idea that Bamia is a hybrid between okra and cotton is shown to be incorrect. The cultivation of Bamia in Egypt is said to require more irrigation than the ordinary kinds.

The yield of lint from Sea Island cotton is less than that from any other kind grown in this country, but on account of the length and quality of the fiber it is adapted to uses to which the other kinds are not suited, and its high market value compensates for the small yield.

The botanical species from which have been developed the multitudinous forms of upland cotton is of less certain restriction. Scarcely any of the authors agree in some of the most important particulars when discussing its origin. However, the weight of opinion seems to be that the species is either *G. herbaceum* or *G. hirsutum*, and as these are considered synonyms their description is combined under the name of the former.

¹ Cultivation of Cotton in India.

² Jour. Linn. Soc., XIX, p. 213.

³ Flora of British India.

⁴ Kew Report, 1887, p. 26.

G. herbaceum Linn.—Shrubby, perennial, but in cultivation herbaceous, annual or biennial. Pubescence variable, part being long, simple or stellate, horizontal or spreading, sometimes short, stellate, abundant, or the plants may be hirsute, silky, or all pubescence may be more or less wanting, the plants being glabrous or nearly so. Glands more or less prominent. Stem terete, or somewhat angled above, branching. Branches spreading or erect. Leaves alternate, petioled, the petioles

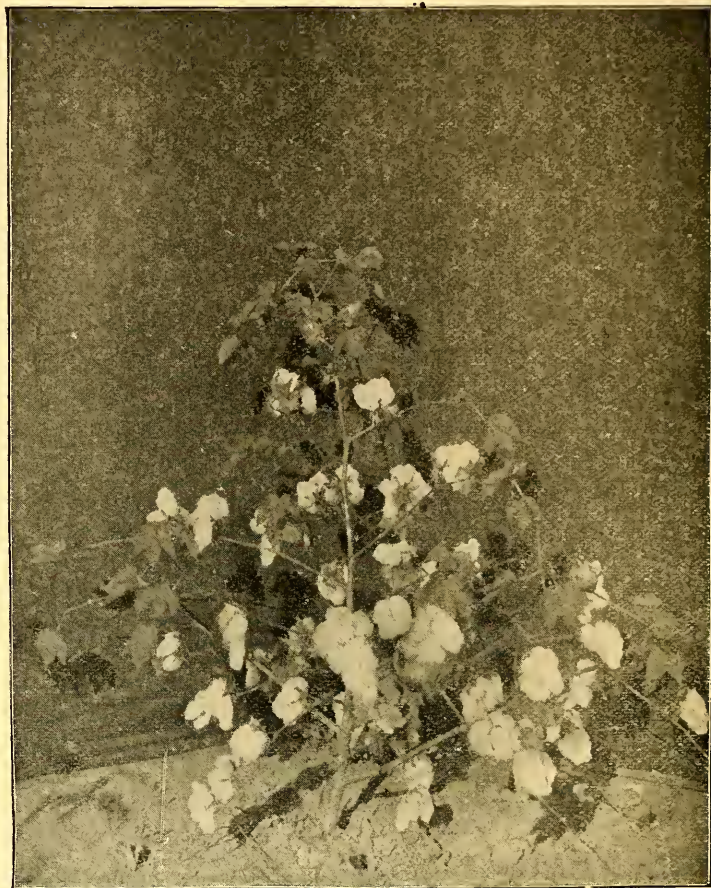


FIG. 2.—Upland cotton (from photograph furnished by Georgia Experiment Station).

about equaling the blades, cordate or subcordate, 3 to 5, rarely 7-lobed. Lobes from oval to ovate, acuminate, pale green above, lighter beneath, more or less hairy on the veins, 3 to 5 or 7-veined, the midvein and sometimes the nearest lateral veins glandular toward the base or glands wanting. Sinus obtuse. Lower leaves sometimes cordate, acuminate, entire, or slightly lobed. Stipules erect or spreading, ovate-lanceolate to linear lanceolate, acuminate, entire or occasionally somewhat dentate. Peduncles erect in flower, becoming pendulous in fruit. Involucre 3,

rarely 4 parted, shorter than the corolla, appressed spreading in fruit, broadly cordate, incisely serrate, the divisions lanceolate, acuminate, entire or sometimes sparingly dentate. Calyx less than half the length of the involucre, cup-shaped, dentate, with short teeth. Petals erect, spreading, obovate or cuneate, obtuse or emarginate, curled or crenulate, white or pale yellow, usually with a purple spot near the base, in age becoming reddish. Stamens half the length of the corolla. Pistil equal or longer than the stamens. Ovary rounded, obtuse or acute, glandular, 3 to 5 celled. Style about twice the length of the ovary, 3 to 5 parted above, the glandular portion often marked with 2 rows of glands. Capsule erect, globose or ovate, obtuse or acuminate, mucronate, pale green, 3 to 5 celled. Valves ovate to oblong, with spreading tips. Seed 5 to 11 in each cell, free, obovate to subglabrous, narrowed at base, clothed with two forms of fiber, one short and dense, closely enveloping the seed, the other 2 to 3 times the length of the seed white, silky, and separating with some difficulty. Cotyledons somewhat glandular punctate.

This species includes in its synonyms the following: *G. album* Hamilton, *G. chinense* Fisch. and Otto, *G. croceum* Hamilton, *G. eglandulosum* Cav., *G. elatum* Salisb., *G. glandulosum* Steud., *G. hirsutum* Linn., *G. indicum* Lam., *G. latifolium* Murr., *G. leoninum* Medic., *G. macedonicum* Murr., *G. micranthum* Cav., *G. molle* Mauri, *G. nanking* Meyen, *G. obtusifolium* Roxb., *G. paniculatum* Blanco, *G. punctatum* Guil. and Perr., *G. religiosum* Linn., *G. siamense* Tenore, *G. sinense* Fisch., *G. strictum* Medic., *G. tricuspidatum* Lam., and *G. vitifolium* Roxb., together with numerous others the descriptions of which are too indefinite or the specimens too meager to determine them positively.

The origin of this series is much more confused than that of the Sea Island cotton. If we separated the upland cotton into two species, viz, *G. herbaceum* and *G. hirsutum*, probably the question would no doubt be simplified, as the former is generally considered of Asiatic origin, while the other is attributed to America. Todaro¹ claims that the form called by him *G. hirsutum* originated in Mexico, from whence it has been spread by cultivators throughout the warmer portions of the world. To this form he ascribes the Georgia upland cotton or the long-staple upland cotton. Parlatore² considers it indigenous to some of the islands of the Gulf of Mexico as well as the mainland, and all green-seeded cotton, which is cultivated so widely, as originating from this form. On the other hand, he claims³ India, especially the shores of Coromandel, as the primitive home of *G. herbaceum*, from which place it has spread as extensively as its western congener, and is found in cultivation in nearly the same regions. Todaro says⁴ that *G. herba-*

¹ Rel. sulla coltura dei cotonei in Italia, 1877-78, p. 212.

² Le specie dei cotonei, p. 43.

³ Ibid., p. 33.

⁴ Rel. sulla coltura dei cotonei in Italia, p. 132.

ceum is spontaneous in Asia and perhaps also in Egypt, and he claims *G. wightianum* as the primitive form of the Indian cottons. Maxwell T. Masters¹ claims *G. stocksii* as the original of all the cultivated forms grouped under *G. herbaceum*. Others consider *G. herbaceum* as a native of Africa, and it seems impossible from the mass of conflicting evidence to determine just where it did originate. It seems probable that *G. herbaceum* is not a definite species, but one developed by cultivation from, perhaps, several wild species, and it represents not a species but a group of hybrids and forms more or less closely related. However, if we consider it as a definite species, no violence is done in claiming it as indigenous to as widely separated regions as America and Asia, nor is it necessary to assume the migration from one place to the other, but rather to consider it an example of simultaneous evolution of a species in opposite portions of the globe without any communication between the progenitors of the species, examples of which are well known. It is a case of evolution influenced by like conditions, and it is probable that the needs of man entered very largely into the development by the selection of certain characters which it was desirable to perpetuate.

The cottons usually called "nankeen" are only color variations of the above, and may be found in nearly every species that is cultivated. Authorities agree that in all probability the yellow lint is the wild form of all cottons, and this character can not be used to designate species.

Species of secondary importance that may be occasionally met in this country, or species thought to be worthy of introduction, although their value is certainly less than those furnishing the staple crop, are as follows:

G. arboreum Linn.—Shrubby perennial, but in cultivation sometimes annual or biennial; tomentose with two forms of hairs, one long and simple, the other more numerous, shorter, and stellate; glands small, scarcely prominent, more or less scattered. Stem erect, terete, very branching. Branches spreading, terete. Leaves alternate, petiolate, with petioles a little shorter than the blade, subcordate, 5 to 7 lobed, lobes oblong-lanceolate or lanceolate-acuminate, bristle-tipped, scarcely channeled above; sinus obtuse, often with a small lobe in some of the sinuses, beneath pale green and softly pubescent, 5 to 7 veined, the mid-vein and often the two adjacent ones with a reddish-yellow gland near their base; upper leaves palmately 3 to 5 lobed, lobes short. Stipules erect, spreading, lanceolate, acuminate. Peduncles axillary, erect before and spreading or horizontal after flowering and drooping in fruit, about three-fourths the length of the petioles, terete, destitute of glands, 1 to 2, usually 1-flowered, jointed above the middle, bearing a small leaf and 2 stipules at this point. Involucre 3-parted, appressed or scarcely spreading at summit, many-nerved, broadly and deeply cordate, ovate, acuminate, 5 to 9, rarely 3 dentate or nearly entire. Calyx much shorter

¹ In Hooker's Flora of British India.

than the bracts, subglobose, truncate, crenulate or subdentate, with a large gland at the base within the involucre. Corolla campanulate, petals erect or spreading, broadly cuneate, subtruncate, crisp or crenulate, purple or rose colored, with a large, dark-purple spot at the base. Staminal tube about half the length of the corolla. Pistils equaling or a little longer than the stamens. Ovary ovate, acute, glandular, usually 3 celled. Style little longer than the ovary, 3-parted, without glands. Capsule pendulous, a little longer than the persistent involucre, ovate rounded, glandular, 3 to 4 celled, and valved. Valves ovate-oval, spreading, mucronate-acuminate, the mucro recurved. Seed 5 to 6, ovate, obscurely angled, black. Fiber two forms, one white, long, overlying a dark-green or black down; not readily separable from the seed.

This species of cotton appears to be indigenous to India and the regions bordering on the Indian Ocean. According to Watt,¹ it is found near temples and in gardens, where it is said to be in flower most of the year. The plant is a perennial, lasting for five or six years or longer, and is not used as a field crop. The fiber is fine, silky, and an inch or more in length, but little of it is produced. The cultural name given it is Nirma or Deo cotton, and its use is said to be restricted to making thread for the turbans of the priestly class. Its value is said to be greatly overrated. This species is sometimes known as *G. religiosum*.

G. neglectum Tod.—Stem erect. Branches slender, graceful, spreading. Leaves, lower ones 3 to 7 palmately lobed, segments lanceolate, acute, rarely bristle-tipped, sinus rounded, the small lobes in the sinuses less distinct than in the previous species, upper leaves 3-parted. Stipules next the peduncles semiovate, dentate, the others linear-lanceolate, acute. Peduncles with short lateral branches, 2 to 4 flowered. Involucral bracts coalescent at base, deeply and acutely laciniate. Petals less than twice the length of the involucral bracts, obovate, unequally cuneate, yellow, with a deep-purple spot at base. Stamen-tube half the length of the corolla, naked at base. Capsule small, ovate, acute, cells 5 to 8 seeded, seed obovate, small, clothed with two forms of fiber, one very short, closely adherent, and of an ashy-green color, the other longer, rather harsh, white.

This species, indigenous to India, is very similar to *G. arboreum*, and by some is thought to be a hybrid between that species and some other, or it may be only a cultural form of the first. It is a large bush, although sometimes only 18 inches in height, and is extensively grown in India as a field crop. It is the Dacca cotton of Royle and Roxburgh and the China cotton of the same authors. This species is cultivated in Bengal, the Punjab, and the Northwest Provinces, and it constitutes to a large extent the Bengal cotton of commerce.² Todaro³ has separated from the species two varieties—*roxburghianum* and *chinense*—

¹ Diet. Economic Products of India, Vol. IV, p. 5.

² Ibid., p. 7.

³ Rel. sulla coltura dei cotonei in Italia, p. 169.

corresponding to the Dacca and China cottons above mentioned. It is very probable that both the varieties and the species are not well founded, but are cultural forms. There is another Indian species, *G. wightianum* Tod., that is claimed to be the form chiefly cultivated in India. It greatly resembles the *G. herbaceum* of India, but differs from that species in that the latter has broader and more rounded leaves, and broader, thinner, and deeper cut bracteoles. It is characterized as follows:

G. wightianum Tod.—Stems erect, somewhat hairy, branches spreading and ascending. Leaves when young densely covered with short, thick, stellate hairs, becoming nearly glabrate in age; ovate-rotund, scarcely cordate, 3 to 5 rarely 7 lobed, lobes ovate, oblong, acute, constricted at base into a rounded sinus. Stipules on the peduncles almost ovate, others linear-lanceolate, acuminate. Flowers yellow with a deep-purple spot at base, becoming reddish on the outside in age. Bracteoles small, slightly united at base, ovate, cordate, acute, shortly toothed. Peduncles erect in flower, recurved in fruit, one-fourth the length of the petioles. Capsule small, ovate, acute, 4-celled, with 8 seeds in each cell. Seeds small, ovate, subrotund, clothed with two forms of fiber, the inner short and closely adhering, other longer, white or reddish.

This species is said to readily hybridize with *G. neglectum*, and numerous species have been founded upon these cultural forms. Among these hybrids are some of the most valuable of Indian cottons.

The typical forms of the foregoing species of cotton have their seed free from each other, but there is another group in which the seed of each cell are closely adherent in an oval mass, from which appearance they are called "kidney" cottons. Most if not all these species are tropical, and their presence in this country as anything more than curiosities is highly improbable. The most important of them is *G. brasiliense* Macfad., and in addition to the fact of the seed adhering in clusters the species is an arborescent plant with very large, 5 to 7 divaricate lobed leaves and very deeply laciniate involucre bracts. The cottons of South America, known to the trade as Pernambuco, Ceara, Santos, etc., are evidently not of this species, but belong to the *G. barbadense* and *G. herbaceum* series.

The physiology and histology of the cotton plant seem to be subjects that have been almost wholly ignored by investigators, and the only references to these subjects are for the most part very general.

According to Heuzé,¹ the time required for the maturity of a cotton crop is divided as follows: From seeding to flowering, New Orleans 80 to 90 days, Sea Island 100 to 110 days; from flowering to maturity, New Orleans 70 to 80 days, and Sea Island about 80 days, making the total period of growth about 5 to 6½ months. According to the same authority, the best average daily temperature for the growth of cotton

¹ *Plantes Industrielles*, Vol. I, p. 139.

is from 60° to 68° F. for the period from germination to flowering and from 68° to 78° from flowering to maturity. Dr. Wight¹ says that for the proper maturity of the best qualities of American cotton an increasing temperature during the period of greatest growth is required. The failure to produce in India a quality of fiber equal to the American product from the same kind of seed is attributed to the fact that in the climate of the former there exists a diminishing rather than an increasing average daily temperature.

The effect of too much rain is to form too much plant and not enough fruit, while serious drought causes a stunted growth of the plant in which few bolls are formed and these ripen prematurely. In the latter case the resultant crop is generally short in staple and poor in quality.

The structure of the cotton fiber has been studied to a considerable extent, and the works of Bowman² and Monie³ may be considered as standard on this part of the subject. The first thing noticed in comparing samples of cotton is the difference in the length and the fineness of the fiber, and upon these factors almost entirely depends the commercial grading of the crop. The principal species of cotton vary in respect to the length of their fiber within rather constant limits, dependent upon soil, culture, and atmospheric conditions. The following table compiled from numerous measurements taken during a period of years shows the maximum, minimum, and average length of fiber for some of the more important varieties, and also the average diameter of the same:

Length and diameter of the principal cotton fibers.

Variety.	Length of staple.			Average diameter of staple.
	Maximum.	Minimum.	Average.	
	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inch.</i>
Sea Island.....	1.80	1.41	1.61	.000640
New Orleans.....	1.16	.88	1.02	.000775
Texas.....	1.12	.87	1.00	.000763
Upland.....	1.06	.81	.93	.000763
Egyptian.....	1.52	1.30	1.41	.000655
Brazilian.....	1.31	1.03	1.17	.000790
Indian varieties:				
Native.....	1.02	.97	.89	.000844
American seed.....	1.21	.95	1.08	.000825
Sea Island seed.....	1.65	1.36	1.50	.000730

From the above table it will be seen that, as a rule, the longer the fiber the less its diameter. The extreme variation in length of the above fibers, from the figures as shown in the table, is from 0.25 to 0.30 inch. In proportion to their size the variation in diameter is much greater than that shown for the length.

If a very immature boll be cut transversely the cut section will show that it is divided by longitudinal walls into three or more divisions,

¹Jour. Agr. Hort. Soc. India, 7 (1849-50), p. 23.

²Structure of the Cotton Fibre, F. H. Bowman, Manchester, 1881.

³The Cotton Fibre, its Structure, etc., Hugh Monie, Manchester and London, 1890.

and the seed will be shown attached to the inner angle of each division. The seed retain this attachment until they have nearly reached their mature size and the growth of lint has begun on them, when their attachments begin to be absorbed and by the increased growth of the lint the seed are forced to the center of the cavity. The development of the fiber commences at the end of the seed farthest from its attachment, and gradually spreads over the seed as the process of growth continues. The first appearance of the cotton fiber occurs a considerable time before the seed has attained its full growth, and commences by the development of cells from the surface of the seed. These cells seem to have their origin in the second layer of cellular tissue, and force themselves through the epidermal layer, which seems to be gradually absorbed. The cells which originate the fiber are characterized by the thickness of their cell walls when compared with their diameter. The method of growth, according to Bowman,¹ is by the successive linear development of cells, the walls of which are absorbed at the point of contact until an elongated cell is produced, which constitutes the cotton fiber. The continued growth of this mass of fiber assists in bursting open the pod when the period of maturity is reached. The length of the fiber varies considerably on different parts of the seed, being longest on the crown and shortest at the base. It is claimed that the fibers do not attain their full length until the pod has been opened and the fibers are exposed to the drying and ripening effect of the air and sun.

In their earliest stages the young fibers appear circular in section, but with their increase in length the walls become thinner and finally collapse into a flat, thin-walled fiber, in appearance like a thin, transparent ribbon. With the opening of the boll there is a rapid consolidation of the liquid cell contents, which by being deposited on the inner side of the walls give to the fiber a greater thickness and density. As the degree of maturity is increased the fiber once more becomes rounded in section. As this action is not perfectly regular, owing to the unequal pressure and deposition of the cell contents, the fibers become twisted, a character readily recognized under the microscope, and one that distinguishes cotton from any other fiber.

In the early period of their formation the cells are filled with astringent juices whose presence may be recognized by applying the tongue to the cut surface of an immature boll. During the process of ripening these juices are replaced by others of a neutral or saccharine nature, and when perfectly ripe the cotton fiber consists almost entirely of cellulose.

When viewed under a microscope the general appearance of a cotton fiber is that of an irregular, flattened, and somewhat twisted tube, the tubular form sometimes being lost in the completely flattened fiber. The edges of the fiber are somewhat thickened and slightly corrugated.

¹ Structure of the Cotton Fibre, p. 25.

The hollow tubular character and constant diameter of the fiber are maintained for about three-fourths its length, when it tapers to a point, where it is perfectly cylindrical and often solid. From various causes there are often found solid places in the body of the fiber, and where such places exist the quality of the staple is reduced, owing to the inequality with which such fibers take up dyestuffs.

The twist in the fiber, which seems to be an acquired character not possessed by wild cotton, is explained by Monie¹ as follows:

The rotary motion begins with the process of vacuation in the fiber, caused by the withdrawal of some of the fluid in the fiber when the seed begins to ripen, and as this is effected slowly and progressively, beginning near the extremity farthest from the seed and gradually receding toward the base, the free end or point becomes twisted on its own axis several times, thus producing the convoluted form exhibited under the microscope.

In every lot of cotton three classes of fibers may be recognized—(1) unripe, (2) half-ripe, and (3) ripe. These conditions are dependent upon several factors, the most important of which is the gathering of cotton before it has been exposed for a sufficient time to the ripening action of the air and sun. The other cause is due to the different stages of maturity of the filaments on different parts of the same seed. Unripe cotton when examined with the aid of a microscope appears extremely thin and transparent, and usually with little or no twist, and it is of little use for manufacture. When used it contracts and curls up in the warm atmosphere of the factory, causing yarn spun from cotton containing much unripe fiber to depreciate greatly in value. The half-ripe fiber has the same characters, but to a lesser degree, and is more valuable than the former, but it is only the ripe cotton fiber that possesses all the requisites for perfect spinning and dyeing.

The differences of the three kinds of fibers as observed under the microscope are shown in the accompanying figures redrawn from Bowman's *Structure of the Cotton Fibre*.

A perfect cotton fiber consists of four parts—(1) an outer membrane, which constitutes the outside skin of the fiber; (2) the real cellulose, which constitutes 85 per cent of the fiber; (3) a central spiral deposit of a harder nature than the rest of the fiber, and (4) a central secretion that corresponds somewhat to the pith of a quill.

Covering the cotton fiber is a sort of varnish or oleaginous deposit, technically known as cotton wax. This is said by Monie² to amount to about 2 per cent by weight of the fiber, and must be removed before the yarn is dyed, otherwise the coloring will be poorly done. The presence of this substance on the fiber is readily shown by the difficulty with which ordinary cotton absorbs moisture. Absorbent cotton is cotton that has been treated in such a way that all the cotton wax is removed.

The details of treatment that the fiber must be subjected to before

¹The Cotton Fibre, its Structure, etc., p. 25.

²Ibid., p. 24.

spinning and dyeing belong to the technique of those trades, and would be out of place in this article. The theory which explains the power of

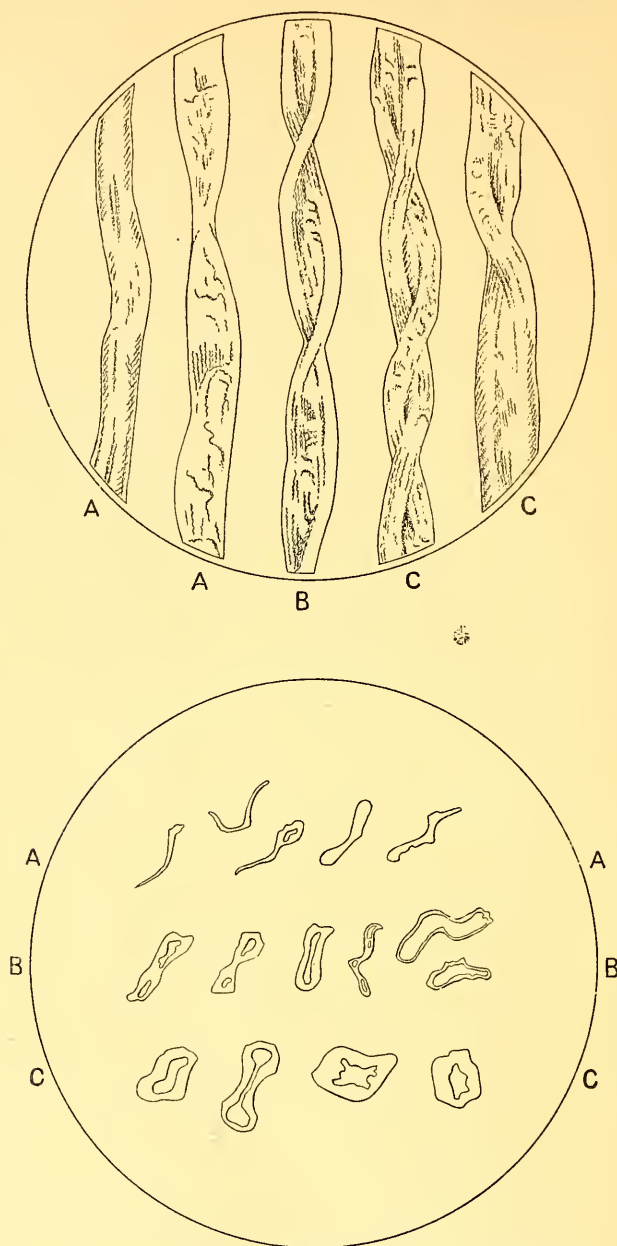


FIG. 3.—Cotton fibers in longitudinal and cross section: AAA, unripe fibers; BB, half-ripe fibers; CCC, fully ripe fibers.

fibers to take up and retain dyes seems not very well authenticated, and is intentionally omitted.

CHEMISTRY OF COTTON.

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Office of Experiment Stations.

As a rule our staple agricultural plants have not received the thorough, systematic chemical investigation that their importance demands. It is true that in many cases the commercial products have been the subject of numerous and sometimes exhaustive chemical studies, but for the plant as a whole, especially with reference to its composition and demands upon the soil at different stages of growth, the analytical data are singularly incomplete and unsatisfactory. This is strikingly true of the cotton plant, of which it has been said: "It is more than probable that less is known of the composition of this plant, with the exception of the seed, than of any other of our staple crops." Although a number of recent studies of the cotton plant have been reported which in a measure supply this deficiency, it will be found that of some 1,500 analyses of the plant and its various parts reported in this article by far the greater number relate to the seed and its products, the rest of the plant, if we except the lint, having usually been ignored.

In the present article chemical data relating to cotton have been collected from every available source and classified and arranged for the use of investigators, little technical discussion of the data being attempted except where it is necessary to emphasize a point not clearly brought out by the tables. As a rule the data used in the text tables have been limited to maxima, minima, and averages of the more important constituents, individual analyses being given only when necessary to illustrate some particular point. A complete compilation of analyses will be found in tables at the end of the article. The order of arrangement is (1) the entire plant and (2) its different parts, beginning with the roots. Under each of the main heads the order is (1) fertilizing constituents, (2) proximate constituents, and (3) miscellaneous chemical studies. This arrangement allows discussion in logical sequence, first, of the chemical data relating to the demands upon the soil and the growth and development of the plant; and second, that relating to the character of the product and its utilization.

ENTIRE PLANT.

FERTILIZING CONSTITUENTS.

The results of available analyses of the entire plant, including the roots, are given in the following table:

Fertilizing constituents of cotton (entire plant).

No.		Date of analysis.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.
1	Young plants collected June 3 (with two leaves) <i>a</i>	1890	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
2	Young plants collected June 23 <i>a</i>	1890	-----	16.21	3.93	2.10	1.96	4.70	1.15
3	Mature plants	1857	-----	4.57	-----	.44	<i>b</i> 1.17	.82	.46
4	do	1890	7.36	5.81	1.46	.44	1.32	1.42	.52

a Water free.*b* Potash and soda.

The data are too limited and unsatisfactory to warrant averages. The analyses of young plants collected June 23 show a decrease in the percentages of ash constituents, especially phosphoric acid, from those found in plants collected twenty days earlier.

In connection with investigations on the effect of different fertilizers on the composition of cotton grown on poor and fertile soils, Anderson¹ has made analyses of the above ground portion of cotton plants in the flowering and bolling stages, the principal results of which are given in the table below:

Fertilizing constituents in dry matter of cotton plants grown with different fertilizers on poor and fertile soil.

	Potash.		Phosphoric acid.		Nitrogen.	
	Flower- ing stage.	Bolling stage. <i>a</i>	Flower- ing stage.	Bolling stage. <i>a</i>	Flower- ing stage.	Bolling stage. <i>a</i>
Poor soil:	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
No fertilizer	2.03	1.26	0.93	0.79	3.49	1.88
Nitrogen	-----	-----	.86	-----	3.91	-----
Potash	2.75	-----	-----	-----	3.38	-----
Phosphoric acid	-----	-----	.78	-----	3.84	-----
Nitrogen and potash	2.14	2.12	.63	.35	3.86	1.97
Nitrogen and phosphoric acid	1.82	1.05	.70	.54	3.69	1.88
Potash and phosphoric acid	2	2.12	.92	.49	3.97	1.84
Nitrogen, potash, and phosphoric acid	2.55	2.56	.83	.56	3.65	1.83
Fertile soil:						
No fertilizer	3.14	2.61	.83	.74	3.99	2.31
Nitrogen	3.29	-----	.83	-----	3.98	-----
Potash	3.32	-----	.96	-----	3.72	-----
Phosphoric acid	3.23	-----	.91	-----	3.90	-----
Nitrogen and potash	2.98	2.03	.81	.74	3.83	2.44
Nitrogen and phosphoric acid	3.20	1.40	.85	.69	4.23	2.06
Potash and phosphoric acid	3.10	2.75	.80	.90	3.87	2.44
Nitrogen, potash, and phosphoric acid	3.61	3.05	.86	.70	4.35	2.34
Average	2.79	2.10	.83	.65	3.85	2.10

a Small, immature seed removed before analysis.¹ Alabama College Sta. Bul. 57.

The table shows that the proportions of fertilizing constituents of the cotton plant vary greatly with varying conditions of soil, fertilization, etc. From this study Anderson concludes—

(1) That the composition of the cotton plant, in respect to potash, phosphoric acid, and nitrogen, is subject to decided variation under varying conditions.

(2) That the nature of the soil exerts a considerable influence on the composition of the plant, a rich soil giving higher percentages of the three important constituents than a poor soil.

(3) By fertilizing with either of the three constituents in soils not already containing a sufficiency of the same it is possible to increase the percentage of that constituent in the cotton plant which is grown in such soil.

The averages also show a notable decrease in the per cent of fertilizing constituents as the period of growth advances.

Studies along this line, including studies of the proximate constituents as well as fertilizing constituents, will undoubtedly prove of the greatest value in elucidating the principles of the nutrition of the cotton plant and in developing a rational system of fertilization which will admit of general application.

The plan so successfully followed by European investigators with some of the cereals and adopted by Snyder¹ with such good results in work of this character on wheat may undoubtedly be applied with advantage to the cotton plant. Anderson, and Hutchinson and Patterson² have made a good beginning in this direction, but their work needs extension and duplication so as to eliminate local and individual peculiarities before generalizations are safe or even possible.

Draft of the cotton plant on the soil.—In this connection we may appropriately discuss the demands of the cotton plant upon the fertility of the soil as indicated by the chemical analyses thus far made. In order to do so intelligently, we must know the relative proportions of the different parts of the plant; but it should be understood in using the table below that however carefully they may have been obtained, the figures there reported represent the results of examinations of cotton plants, grown under one set of conditions only, and that the proportions are likely to vary greatly with variations of soil, season, fertilizers, etc. The following table is compiled from data secured by McBryde³ from examinations of a large number of plants:

Proportions of different parts of the cotton plant.

[Water-free.]

	Weight.		Per cent.
	Ounces.	Grams.	
Roots	0. 513	14. 55	8. 80
Stems	1. 350	38. 26	23. 15
Leaves	1. 181	33. 48	20. 25
Bolls .....	. 829	23. 49	14. 21
Seed	1. 343	38. 07	23. 03
Lint .....	. 615	17. 45	10. 56
Total crop	5. 831	165. 30	100

¹ Minnesota Sta. Bul. 29.

² Mississippi Sta. Tech. Bul. 1.

³ Tennessee Sta. Bul., Vol. IV, No. 5.

Calculating the averages of the analyses of the different parts to the basis given in the above table, we find the amounts of soil ingredients removed by a crop yielding 100 pounds of lint per acre:

Fertilizing constituents in a crop of cotton yielding 100 pounds of lint per acre.

[Pounds per acre.]

	Nitrogen.	Phos- phoric acid.	Potash.	Lime.	Mag- nesia.
Roots (83 pounds)	0.76	0.43	1.06	0.53	0.34
Stems (219 pounds)	3.20	1.29	3.09	2.12	.92
Leaves (192 pounds)	6.16	2.28	3.46	8.52	1.67
Bolls (135 pounds)	3.43	1.30	2.44	.69	.54
Seed (218 pounds)	6.82	2.77	2.55	.55	1.20
Lint (100 pounds) .....	.34	.10	.46	.19	.08
Total crop (847 pounds)	20.71	8.17	13.06	12.60	4.75

McBryde has shown "that even when the seed is taken away along with the lint, cotton still removes smaller amounts of fertilizing materials from the soil than either oats or corn." It is an important fact that the lint and the oil, whose fertilizing constituents alone are necessarily permanently lost to the farm, contain comparatively insignificant amounts of these constituents. If, therefore, the roots, stems, leaves, etc., are turned under, and the hulls and meal used on the farm upon which the cotton was grown, cotton is the least exhaustive of the staple crops to the soil.¹

PROXIMATE CONSTITUENTS.

In the following table are given three proximate analyses of the whole plant and three of plants with seed cotton removed. Nos. 2 and 3 are of very young plants. At the date of No. 2 the plant had only two leaves. No. 1 is of the fully matured plant:

Proximate constituents of cotton (entire plant).

No.		Date of analy- sis.	Water.	Ash.	Protein.	Fiber.	Nitro- gen- free ex- tract.	Fat.
			<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1	Collected Oct. 25	1890	7.36	5.81	9.13	30.94	42.84	3.92
2	Collected June 3	1890	<i>a</i> 10.76	15.62	21.49	16.38	32.51	4
3	Collected June 23	1890	<i>a</i> 10	14.59	22.09	18.79	29.98	4.55
	Average			12.01	17.57	22.04	35.11	4.15
4	Plant with seed cotton removed	1882	6.51	5.30	6.06	35.33	44.18	2.62
5	.....do	1890	10.76	5.34	5.67	40.27	36.92	1.04
6	.....do	1893	12.77	7.75	7.31	27.55	42.35	1.98
	Average		10.01	6.13	6.35	34.38	41.15	1.98

a Assumed.

¹As will be shown in subsequent chapters, the exhaustion of the soil by cotton culture is due very largely to the fact that the soil lies bare for a large part of the year.

ROOTS.

FERTILIZING CONSTITUENTS.

The roots, as shown above, constitute 8.8 per cent of the entire plant. Data from analyses of 14 samples of roots collected at different stages of growth are compared in the following table, the maximum, minimum, and average composition being compiled from 18 separate analyses:

Fertilizing constituents of cotton roots.

No.		Date of analysis.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.
			<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1	Collected July 2.....	1890	<i>a</i> 10	6.52	1.13	0.68	1.69	1.03	0.59
2	Collected July 12.....	1890	<i>a</i> 10	4.87	1.07	.57	1.28	.85	.55
3	Collected July 22.....	1890	<i>a</i> 10	4.18	.91	.36	.99	.53	.41
4	Collected Aug. 1.....	1890	<i>a</i> 10	6.54	1.15	.92	1.30	.91	.81
5	Collected Aug. 11.....	1890	<i>a</i> 10	4.04	.94	.55	.96	.76	.49
6	Collected Aug. 22.....	1890	<i>a</i> 10	3.01	.92	.31	.70	.49	.34
7	Collected June 18.....	1891	<i>a</i> 10	7.23	1.58	.66	3.10	.69	.56
8	Collected June 28.....	1891	<i>a</i> 10	4.78	.96	.60	1.89	.48	.42
9	Collected July 8.....	1891	<i>a</i> 10	4.18	.86	.58	1.48	.43	.39
10	Collected July 18.....	1891	<i>a</i> 10	4.25	.97	.59	1.57	.40	.41
11	Collected July 28.....	1891	<i>a</i> 10	3.29	.57	.50	.94	.46	.36
12	Collected Aug. 7.....	1891	<i>a</i> 10	3.48	.71	.47	.95	.36	.31
13	Collected Aug. 17.....	1891	<i>a</i> 10	3.21	.52	.45	1.03	.43	.26
14	Collected Aug. 28.....	1891	<i>a</i> 10	3.54	.47	.49	.71	.42	.26
18 analyses {			Minimum.....	6.93	3.01	.47	.14	.70	.36
			Maximum.....	10	7.23	1.58	.92	3.10	1.18
			Average.....	9.66	4.50	.92	.49	.64	.41

a Assumed.

We notice here, as in case of the analyses of the entire plant, a decrease in the percentage of total ash as the season advances. The nitrogen and potash also decrease under the same circumstances. The phosphoric acid, while somewhat irregular, shows a tendency to decrease. The same appears to hold true of the lime and magnesia, indicating a more active assimilation of fertilizing constituents during the early growth of the plant than in the later stages. Still, the variations are sufficiently irregular during the two seasons to emphasize the need of more extended investigations in order to establish the laws governing the nutrition of this part of the plant.

PROXIMATE CONSTITUENTS.

The table below shows the proximate constituents of the roots at various stages of growth during two years, the maxima, minima, and averages being compiled from 15 analyses:

Proximate constituents of cotton roots.

No.		Date of analysis.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	Collected July 2.....	1890	<i>a</i> 10	6.52	7.04	42.35	31.95	2.14
2	Collected July 12.....	1890	<i>a</i> 10	4.87	6.71	41.13	34.87	2.42
3	Collected July 22.....	1890	<i>a</i> 10	4.18	5.67	43.94	33.62	2.59
4	Collected Aug. 1.....	1890	<i>a</i> 10	6.54	7.20	42.28	31.79	2.19
5	Collected Aug. 11.....	1890	<i>a</i> 10	4.04	5.87	48.40	30.26	1.43
6	Collected Aug. 22.....	1890	<i>a</i> 10	3.01	5.75	43.73	34.88	2.63
7	Collected June 18.....	1891	<i>a</i> 10	7.23	9.89	41.98	29.14	1.76
8	Collected June 28.....	1891	<i>a</i> 10	4.78	6.03	41.85	36.38	.96
9	Collected July 8.....	1891	<i>a</i> 10	4.18	5.35	38.55	39.15	2.77
10	Collected July 18.....	1891	<i>a</i> 10	4.25	6.08	45.32	32.44	1.91
11	Collected July 28.....	1891	<i>a</i> 10	3.29	3.65	45.51	35.41	2.14
12	Collected Aug. 7.....	1891	<i>a</i> 10	3.48	4.45	47.27	33.31	1.49
13	Collected Aug. 17.....	1891	<i>a</i> 10	3.21	3.29	44.71	37.04	1.75
14	Collected Aug. 28.....	1891	<i>a</i> 10	3.54	2.92	47.29	34.00	2.25
15 analyses {		Maximum.....		7.23	9.89	48.57	39.15	2.77
		Minimum.....		3.01	2.92	38.55	29.14	.96
		Average.....		4.43	5.60	44.19	33.92	2.04

a Assumed.

The crude fiber fluctuated both years, though the tendency was to increase. The protein fluctuated also, and was very different for the two seasons. In 1890 it remained nearly the same throughout the season, while in 1891 the tendency was rapidly downward, being at the end about one-third what it was at the beginning and about half what it was at the close of 1890. The ether extract and carbohydrates also fluctuated, both being higher, as a rule, the latter season. The ash fluctuated a little both years, but the tendency was to become less. At the close it was half what it was at the beginning of the season.¹

MEDICINAL PROPERTIES.

Cotton-root bark (*Gossypii radidis cortex* U. S. P.) contains a chemical substance similar in its action to ergot. The active property appears to reside in a red resin, but as far as can be ascertained no separated principle, representing the full activity of the bark, has yet been extracted from the drug. E. S. Wayne in an article entitled "Medicinal properties of cotton roots"² gives the results of a study of the chemical properties of this drug.

STEMS.

FERTILIZING CONSTITUENTS.

The stems constitute about 23 per cent of the entire plant. The following table shows the fertilizing constituents of stems at various stages of growth. The maxima, minima, and averages are compiled from 20 analyses.

¹ Mississippi Sta. Tech. Bul. 1.² Amer. Jour. Pharm., 1872, p. 287.

Fertilizing constituents of cotton stems.

No.		Date of analysis.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.
			<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1	Collected July 2.....	1890	<i>a</i> 10	6.63	1.66	0.66	1.79	1.48	0.68
2	Collected July 12.....	1890	<i>a</i> 10	5.39	1.66	.71	1.18	1.28	.67
3	Collected July 22.....	1890	<i>a</i> 10	6.10	1.59	.51	1.49	1.30	.63
4	Collected Aug. 1.....	1890	<i>a</i> 10	5.41	1.60	.47	1.36	1.12	.67
5	Collected Aug. 11.....	1890	<i>a</i> 10	3.93	1.03	.51	1	.83	.44
6	Collected Aug. 22.....	1890	<i>a</i> 10	2.75	.96	.26	.68	.56	.31
7	Collected June 18.....	1891	<i>a</i> 10	9.64	3.28	1.08	3.91	1.32	.72
8	Collected June 28.....	1891	<i>a</i> 10	6.44	1.76	.76	2.35	1.13	.50
9	Collected July 8.....	1891	<i>a</i> 10	5.31	1.78	.78	1.93	.94	.47
10	Collected July 18.....	1891	<i>a</i> 10	5.22	1.54	.74	1.76	.88	.47
11	Collected July 28.....	1891	<i>a</i> 10	4.44	1.68	.88	1.34	.85	.35
12	Collected Aug. 7.....	1891	<i>a</i> 10	4.27	1.63	.67	1.25	.82	.31
13	Collected Aug. 17.....	1891	<i>a</i> 10	4.07	1.10	.64	1.43	.73	.22
14	Collected Aug. 28.....	1891	<i>a</i> 10	3.92	1	.49	1.04	.83	.22
20 analyses {			Minimum.....	8.41	2.34	.74	.17	.26	.10
			Maximum.....	11.71	9.64	3.28	1.08	3.91	.72
			Average.....	10.01	4.80	1.46	.59	1.41	.42

a Assumed.

The same general tendencies observed in case of the roots are noticed here, but the variations are more irregular.

PROXIMATE CONSTITUENTS.

The table below gives 15 proximate analyses of the stems. Analyses from 1 to 14, inclusive, show the composition of the stem at different stages of growth, and No. 15 is of fully matured plants.

Proximate constituents of cotton stems.

No.		Date of analysis.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	Collected July 2.....	1890	<i>a</i> 10	6.63	10.40	40.37	31.04	1.56
2	Collected July 12.....	1890	<i>a</i> 10	5.39	10.40	42.81	30.27	1.13
3	Collected July 22.....	1890	<i>a</i> 10	6.10	9.94	41.65	30.77	1.54
4	Collected Aug. 1.....	1890	<i>a</i> 10	5.41	10.02	48.17	25.89	1.41
5	Collected Aug. 11.....	1890	<i>a</i> 10	3.93	6.49	47.36	30.22	2.00
6	Collected Aug. 22.....	1890	<i>a</i> 10	2.75	6.04	49.44	29.75	2.02
7	Collected June 18.....	1891	<i>a</i> 10	9.64	20.45	32.51	25.59	1.81
8	Collected June 28.....	1891	<i>a</i> 10	6.44	11.02	37.56	33.27	1.71
9	Collected July 8.....	1891	<i>a</i> 10	5.31	11.13	34.64	36.43	2.49
10	Collected July 18.....	1891	<i>a</i> 10	5.22	9.60	33.32	39.87	1.99
11	Collected July 28.....	1891	<i>a</i> 10	4.44	10.50	39.95	31.61	3.50
12	Collected Aug. 7.....	1891	<i>a</i> 10	4.27	10.16	36.61	33.15	2.21
13	Collected Aug. 17.....	1891	<i>a</i> 10	4.07	6.87	42.54	34.88	1.64
14	Collected Aug. 28.....	1891	<i>a</i> 10	3.92	6.25	42.71	35.51	1.61
15	Mature plant.....	1889	10.06	4.09	4.90	45.16	35.04	.81
16 analyses {			Maximum.....	9.64	20.45	49.44	39.87	3.50
			Minimum.....	2.75	4.90	32.51	25.59	.81
			Average.....	10	5.23	40.77	32.63	1.83

a Assumed.

Though it fluctuated, the crude fiber in the stem increased as the plant matured. The protein fluctuated, but the tendency was to decrease, and this was very marked at the later periods of growth, when the bolls were forming. The ether extract fluctuated, increasing at the close in 1890 and decreasing at the same period in 1891. The carbohydrates remained nearly constant the first year throughout the period of growth, but increased slightly during the latter period as the plant grew older.¹

¹ Mississippi Sta. Tech. Bul. 1.

LEAVES.

FERTILIZING CONSTITUENTS.

The leaves have been found to be a little over 20 per cent of the plant. The following table gives 16 analyses of the mineral matter of the leaves. Nos. 1 and 2 are from mature plants. Nos. 3 to 16 are from the same samples reported in previous tables, and show the chemical changes taking place in leaves during a part of their period of growth:

Fertilizing constituents of cotton leaves.

No.		Date of analysis.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.
			<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1	Leaves of mature plants	1889	9.50	16.42	2.37	0.46	0.83	7.08	1.26
2	Leaves of mature plants	1890	12.14	12.05	2.45	.42	1.33	4.10	.76
3	Collected July 2.	1890	<i>a</i> 10	13.68	3.80	1.08	2.63	5.28	1.26
4	Collected July 12.	1890	<i>a</i> 10	14.09	3.92	1.06	1.58	5.31	1.23
5	Collected July 22.	1890	<i>a</i> 10	14.99	3.80	.83	1.48	5.63	.99
6	Collected Aug. 1.	1890	<i>a</i> 10	15.32	3.65	1.03	1.27	5.27	1.28
7	Collected Aug. 11.	1890	<i>a</i> 10	12.33	3.21	.72	1.21	4.61	.98
8	Collected Aug. 22.	1890	<i>a</i> 10	13.08	3.11	1.21	1.65	4.66	1.03
9	Collected June 18.	1891	<i>a</i> 10	11.92	4.27	1.06	2.36	3.83	.66
10	Collected June 28.	1891	<i>a</i> 10	12.17	3.87	1.45	2.54	3.65	.66
11	Collected July 8.	1891	<i>a</i> 10	11.38	3.73	1.54	1.93	3.68	.81
12	Collected July 18.	1891	<i>a</i> 10	11.57	3.55	1.76	2.21	3.75	.77
13	Collected July 28.	1891	<i>a</i> 10	13.73	3.53	2.08	1.99	4.87	.93
14	Collected Aug. 7.	1891	<i>a</i> 10	11.86	3.35	1.69	1.59	3.89	.68
15	Collected Aug. 17.	1891	<i>a</i> 10	11.93	3.03	1.57	1.89	3.56	.60
16	Collected Aug. 28.	1891	<i>a</i> 10	10.73	2.67	1.54	1.72	3.67	.82
19 analyses {			Minimum	9.50	9.33	1.41	.42	.83	.07
			Maximum	12.14	17.26	4.27	2.08	2.63	1.28
			Average	10.10	13.11	3.21	1.19	4.44	.87

a Assumed.

That there is slight decrease of total ash as the period of growth advances is indicated, although this is by no means regular. There is also a slight though fluctuating tendency to a decrease in all of the individual fertilizing constituents except phosphoric acid, which shows irregular but considerable increase.

PROXIMATE CONSTITUENTS.

The table below gives 15 proximate analyses of the leaves at various stages of growth; they show the chemical changes which take place as the plant advances in maturity.

Analysis No. 1 is of the leaves of mature plants, as may be seen by the results:

Proximate constituents of cotton leaves.

No.		Date of analysis.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	From mature plants	1889	10.82	14.24	15.06	10.04	43.32	6.52
2	Collected July 2	1890	<i>a</i> 10	13.68	23.76	13.69	34.51	4.36
3	Collected July 12	1890	<i>a</i> 10	14.09	24.53	13.19	33.89	4.30
4	Collected July 22	1890	<i>a</i> 10	14.99	23.77	11.74	34.64	4.86
5	Collected Aug. 1	1890	<i>a</i> 10	15.32	22.84	16.73	29.72	5.39
6	Collected Aug. 11	1890	<i>a</i> 10	12.33	20.08	18.15	35.13	4.31
7	Collected Aug. 22	1890	<i>a</i> 10	13.08	19.46	13.04	37.37	7.05
8	Collected June 18	1891	<i>a</i> 10	11.92	26.64	11.15	36.32	3.97
9	Collected June 28	1891	<i>a</i> 10	12.17	24.19	11.45	37.10	5.09
10	Collected July 8	1891	<i>a</i> 10	11.39	23.29	11.39	37.04	6.89
11	Collected July 18	1891	<i>a</i> 10	11.57	22.17	12.51	37.54	6.21
12	Collected July 28	1891	<i>a</i> 10	13.73	22.06	11.29	35.14	7.78
13	Collected Aug. 7	1891	<i>a</i> 10	11.86	20.94	12.79	37.93	6.48
14	Collected Aug. 17	1891	<i>a</i> 10	11.93	18.98	11.93	38.52	8.64
15	Collected Aug. 28	1891	<i>a</i> 10	10.73	16.74	9.50	44.16	8.87
15 analyses { Maximum .....			.....	15.32	26.64	18.15	44.16	8.87
{ Minimum .....			.....	10.73	15.06	9.50	29.72	3.97
{ Average .....			.....	12.87	21.64	12.57	36.82	6.05

a Assumed.

The proportion of crude fiber in the leaves was small throughout the entire periods of growth, though it fluctuated both seasons; it fell off rapidly at the last period both years. The protein was very high in the leaves, but continually became less as the plant matured. The ether extract increased during the last stages of growth, but fluctuated and was usually higher in 1891, and the same is true of the carbohydrates.¹

BOLLS.

FERTILIZING CONSTITUENTS.

The table below shows analyses of the mineral matter of 6 samples of bolls containing lint and seed and of 3 samples of empty bolls. The latter constitute about 14 per cent of the entire plant:

Fertilizing constituents of cotton bolls.

No.		Date of analysis.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.
			<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1	Bolls collected July 22	1890	<i>a</i> 10	6.02	3.11	1.13	2.08	0.74	0.44
2	Bolls collected Aug. 1	1890	<i>a</i> 10	5.71	2.99	1.08	2.14	.61	.45
3	Bolls collected Aug. 11	1890	<i>a</i> 10	5.25	2.53	1.04	2.09	.41	.40
4	Bolls collected Aug. 22	1890	<i>a</i> 10	5.11	3.03	.98	1.93	.51	.41
5	Bolls collected Aug. 7	1891	<i>a</i> 10	3.87	1.87	.82	1.41	.43	.38
6	Bolls collected Aug. 17	1891	<i>a</i> 10	3.43	1.70	.71	1.21	.37	.35
Average .....			.....	4.90	2.54	.96	1.81	.51	.40
7	Empty burs	1874	.....	12.96	1.03	.89	1.85	3.54	.79
8	do	1889	.....	9.47	7.65	1.36	2.90	1.09	.29
9	do	1890	.....	14.36	7.03	.87	3.23	.77	.21
Average .....			.....	11.92	9.21	1.08	2.66	1.80	.43

a Assumed.

The analyses here, as in previous cases, seem to indicate a decrease in fertilizing constituents as the period of growth advances.

¹Mississippi Sta. Tech., Bul. 1.

PROXIMATE CONSTITUENTS.

Hutchinson and Patterson have reported 6 proximate analyses of this product, as shown in the following table. Analysis No. 4 is of nearly mature bolls. The others are presumably of immature bolls in which the seed and lint are undeveloped.

Analyses at different stages of growth during two years are given to show the development of the plant:

Proximate constituents of cotton bolls.

No.		Date of analysis.	Water.	Ash.	Protein.	Fiber	Nitrogen-free extract.	Fat.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	Bolls collected July 22.....	1890	a 10	6.02	19.48	14.92	46.82	2.73
2	Bolls collected Aug. 1.....	1890	a 10	5.71	18.66	23	38.78	3.85
3	Bolls collected Aug. 11.....	1890	a 10	5.25	15.83	29.73	35.65	3.54
4	Bolls collected Aug. 22.....	1890	a 10	5.11	18.98	30.36	26.85	8.70
5	Bolls collected Aug. 7.....	1891	a 10	3.87	11.73	7.04	64.60	2.76
6	Bolls collected Aug. 17.....	1891	a 10	3.43	10.65	13.27	59.78	2.87
6 analyses	{ Maximum			6.02	19.48	30.36	64.60	8.70
	{ Minimum			3.43	10.65	7.04	26.85	2.73
	{ Average		10	4.90	15.89	19.72	45.42	4.07
Empty burs.....			11.92	7.34	6.96	32.50	39.90	1.38

a Assumed.

The crude fiber in the bolls increased very rapidly as they matured, though it was much higher during the first season. The protein, which fluctuated very little during the first year, was very much higher than it was the second year, and in the last season there was a decline during the last period. The ether extract, which was very constant in quantity during the earlier periods of development of the bolls, increased greatly during the last period in 1890, when all the bolls were nearly matured. The carbohydrates, which were very much higher during the last year, decreased rapidly as the bolls matured.¹

LINT.

FERTILIZING CONSTITUENTS.

Lint constitutes 10.56 per cent of the mature plant. A number of analyses with reference to fertilizing constituents have been made of this material, the results of which are embodied in the following table:

Fertilizing constituents of cotton lint.

No.	Kind of lint.	Date of analysis.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.
			<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1	Sea Island.....			1		0.09	0.48	0.11	0.03
2	Upland.....	1874		1.14		.04	.47	.07	.10
3	do.....	1857		.93		.11	.28	.16	.03
4	do.....	1857	4.72	1.25		.07	.44	.21	.12
5	Sea Island.....	1857		1.31		.16	.28	.18	.06
6	do.....	1857		1.50		.17	.36	.26	.02
7	Short-staple.....	1857		1.50		.06	.44	.11	.03
8	Upland.....	1874		1.75	0.54	.18	.37	.48	.17
9	do.....	1889	6.72	1.50	.28	.07	.64	.16	.11
10	do.....	1890	6.77	1.80	.20	.05	.85	.15	.16
10 analyses	{ Minimum		4.72	.93	.20	.05	.28	.07	.02
	{ Maximum		6.77	1.80	.54	.18	.85	.48	.17
	{ Average		6.07	1.37	.34	.10	.46	.19	.02

¹ Mississippi Sta. Tech. Bul. 1.

This table makes it clear that if the lint were the only part of the plant removed from the land on which it is grown, cotton would be one of the least exhaustive of farm crops. The only other part which need be permanently lost to the soil is the oil, which also contains very small amounts of fertilizing constituents.

Bowman has reported¹ that associated with cotton fiber "there are small quantities of nitrogen, on the average about 0.0345 per cent, but differing in different varieties of cotton. The nitrogen appears to form part of the albuminous matter which was found by Schunck to be contained in the fiber [see p. 92]. * * * In some cases it may also arise from or be increased by the existence of small quantities of nitrates associated with other mineral constituents."²

According to Calvert,³ cotton samples from different countries contain the following percentages of phosphoric acid soluble in water: Egypt, 0.055; New Orleans, 0.049; Bengal, 0.055; Surat, 0.027; Carthagena, 0.035 to 0.050, and Cyprus, 0.050.⁴

PROXIMATE CONSTITUENTS.

The proximate constituents of cotton lint were found by an analysis made at the Tennessee Station to be as follows: Water, 6.74 per cent; ash, 1.65; protein, 1.5; fiber, 83.71; nitrogen-free extract, 5.79, and fat, 0.61, showing that in its crude state, at least, it is far from being the pure cellulose it is often stated to be, a fact abundantly proven by the investigations reviewed on the following pages.

MISCELLANEOUS CHEMICAL STUDIES OF COTTON FIBER.

Structure of cotton fiber.—O'Neill,⁵ by treating cotton fiber with Schweitzer's reagent, succeeded in separating four different constituents: (1) The outside membrane, which did not dissolve in the reagent; (2) the real cellulose beneath, which dissolved, first swelling enormously and dilating the outside membrane; (3) spiral fibers apparently situated in or close to the outside membrane, not readily soluble in the copper solution, and (4) an insoluble substance occupying the cone of the cotton hair. He also made a study of the substance found associated with the cellulose sheath in cotton fiber, to which Schunck has given the name of cotton wax.⁶ The composition of this wax appears to differ slightly with the different kinds of cotton, but an average analysis of wax from American fiber is reported as follows: Carbon 80.38 per cent, hydrogen 14.51 per cent, and oxygen 5.11 per cent.

¹ Structure of the Cotton Fibre, p. 70.

² The figure here given for nitrogen by Bowman, it will be noticed, is much lower than that given in the table above; so much so that it appears possible that his decimal point may be in the wrong place.

³ Compt. Rend., 65 (1867), p. 1150; Jour. prakt. Chem., 1869, II, p. 122.

⁴ For detailed analyses of the ash of the cleaned and uncleaned Sea Island cotton, by Ure, see F. H. Bowman, Structure of the Cotton Fibre, 1882, p. 67.

⁵ Calico Printing, Bleaching, and Dyeing, Vol. II, p. 2; F. H. Bowman, Structure of the Cotton Fibre, 1882, p. 50.

⁶ Mem. Manchester Lit. and Phil. Soc., Vol. IV, 3d ser., p. 95.

The wax fuses at 186.8° F. and solidifies at 179.6° F. The wax from Dholleah cotton differs from that derived from the American fiber in that it does not solidify until it has reached a temperature of 177.8° F. "Along with this wax is also a fatty acid, which is white and solid, and which by analysis has been proven to be identical with margaric acid."

E. Schunck¹ has shown by careful investigation that cotton, instead of being a pure cellulose, "contains a number of other ingredients, some of which occur so constantly that they may be considered essential constituents of cotton viewed as a vegetable product," and which may amount to 13 per cent or even more. This fact had previously been pointed out by Persoz,² who states that the fiber of cotton, hemp, linen, etc., contains (1) a certain quantity of coloring matter, (2) a peculiar resin insoluble in water and soluble with difficulty in alkalies, (3) a small quantity of fatty matter, and (4) inorganic saline matters. Schunck succeeded in separating the following substances: (1) A species of vegetable wax, (2) a fatty acid, (3) two kinds of coloring matter, (4) peptic acid, and (5) a trace of albuminous matter.

Of the two coloring matters³ which Schunck succeeded in separating from Nankin cotton, one was easily soluble in alcohol and was obtained on evaporating the solution as a dark-brown, shiny, transparent residue; the other was almost insoluble in cold alcohol, but dissolved in boiling alcohol, and was deposited on the solution cooling, in the form of a light-brown powder. Their properties are in general the same as those of the analogous coloring matters from ordinary cotton. Their composition was as follows:

	A. Coloring matter solu- ble in cold alcohol.	B. Coloring matter insolu- ble in cold alcohol.
	<i>Per cent.</i>	<i>Per cent.</i>
C	58.22	57.70
H	5.42	5.60
N	3.73	4.99
O	32.63	31.71
Total	100	100

The composition of the analogous coloring matters from American cotton, according to previous determinations, was as follows:

	A.	B.
	<i>Per cent.</i>	<i>Per cent.</i>
C	58.42	58.36
H	5.85	5.71
N	5.26	7.60
O	30.47	28.33
Total	100	100

The difference in composition, in the first case at least, is not greater than may be expected with substances of the purity of which, in consequence of their not occurring in a crystallized state, one can never be perfectly sure. On the whole, I think these experiments justify the conclusion at which I have arrived, viz, that the color of Nankin cotton is due to the presence of bodies which are very similar to, if not

¹ Chem. News (Amer. ed.), 2 (1868), p. 232.

² Traité de l'Impression des Tissus

³ Chem. News, 29 (1874), p. 5.

identical with, those which cause the much fainter tints of the ordinary kinds. They show, too, that the substances accompanying the cellulose (whether clothing the fibers or contained in their interior) are the same with this variety of cotton as with all those previously examined.

Water content of cotton fiber.—F. H. Bowman¹ states that the quantity of water in cotton fibers “varies with different seasons from 1 to about 4 per cent in the new crop, and rather less as the season advances. Above 2 per cent of moisture, however, seems to be an excessive quantity even in a new crop cotton, and when more than this is present it is either the result of a wet season and the cotton has been packed before drying, or else it has been artificially added.”

In testing the quantity of so-called water of hydration, the author found that on heating to 212° F. samples of cotton lost from 5 to 7 per cent in weight, “and when they were replaced in the same room for some days they gradually regained all the weight they had lost.”

Sand and mineral matter in different classes of cotton fiber.—Ure reports determinations of the amount of sand and mineral matter in 12 different classes of cotton. “The samples were taken out of bales upon their arrival in Liverpool.” The results varied from 1.15 (rough Peruvian) to 6.22 (Dhollerah) per cent, with an average of 2.51 per cent, the American cotton containing 1.52 per cent of mineral matter.

As a rule, it may be taken for granted that an excess of ash much above 1 per cent arises from the presence of impurities.

SEED.

Sea Island and Egyptian seeds are both entirely freed from lint by ginning, but with upland cotton seed the lint still adhering to the seed after it has passed through the gin amounts to about 10 per cent of the total weight of the seed.

According to the Tenth Census, the ginned seed yields at the oil mills the following products:

Kernels, 50 per cent, yielding—	Per cent.
Oil	25
Meal	75
	<hr/> 100 <hr/>
Hulls, 50 per cent, yielding—	
Linters	2.2
Hulls	97.8
	<hr/> 100 <hr/>
In the whole seed:	
Meal	37.5
Oil	12.5
Hulls	48.9
Linters	1.1
	<hr/> 100 <hr/>

¹Structure of the Cotton Fibre, 1882, p. 62.

While the figures in these tables indicate how the seed was divided by the oil mills at the time that the data were collected, they do not represent the actual weights of the different parts of the seed. The lint, as we have stated, was found at the South Carolina Station to be 10 per cent by weight of the ginned seed. The North Carolina Station¹ found from a number of tests that the proportion of hulls to kernels was as follows: Hulls, 49.9 per cent; kernels, 50.1 per cent. The Texas Station² found the proportion as follows: Hulls, 45.2 per cent; kernels, 54.8. J. H. Cooper reports:³ Hulls, 42.25; kernels, 57.7. Adriane⁴ states that Egyptian seed shows 37.45 per cent hulls to 62.55 per cent kernels. These figures are in each case the averages of a number of tests where the kernels and hulls were carefully separated by hand, and in each case the lint is included with the hulls. By averaging these results we obtain the following table, which represents very nearly the actual weights of the different parts of the seed:

Kernels, 54.22 per cent, yielding—		Per cent.
Oil		36.88
Meal		63.12
		100
Hulls, 45.78 per cent, yielding—		
Linters		27.95
Hulls		72.05
		100
In the whole seed:		
Meal		34.22
Oil		20
Hulls		35.78
Linters		10
		100

FERTILIZING CONSTITUENTS.

The seed constitutes 23 per cent of the weight of the entire plant. The following table gives a summary of the results of 15 analyses of this part of the plant with reference to fertilizing constituents:

Fertilizing constituents of cotton seed.

	Wa- ter.	Ash.	Nitro- gen.	Phos- phoric acid.	Pot- ash.	Soda.	Lime.	Mag- nesia.	Sul- phu- ric acid.	Fer- ric oxid.	Chlo- rin.	Insol- uble mat- ter.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Minimum.....	7.04	2.80	1.96	0.76	0.73	0.02	0.11	0.40	0.01	0.02	0.02	0.01
Maximum	9.51	4.96	5.17	1.77	1.63	.50	1.15	.79	.27	.13	.18	.12
Average	8.42	3.78	3.13	1.27	1.17	.20	.25	.55	.12	.07	.05	.06

¹North Carolina Sta. Rpt. 1882, p. 93.

²Texas Sta. Bul. 2.

³Southern Cultivator, Vol. III, p. 111.

⁴Chem. News, Jan., 1865.

PROXIMATE CONSTITUENTS.

In the following table is given a summary of the results of 25 proximate analyses of the whole cotton seed, together with similar summaries by Dietrich and König, Wolff, and Kühn:

Proximate constituents of cotton seed.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Dietrich and König's summary:						
Minimum.....	8	2.89	13.62	18.93	7.58	10.40
Maximum.....	11.42	8	29.70	32.40	36.70	29.34
Average (8 analyses).....	9.76	4.86	19.56	23.46	22.45	19.91
Wolff's average.....	11.40	4.30	19.90	18.90	20.20	25.30
Kühn's summary:						
Minimum.....	7.70	-----	22.75	16	7.60	29.30
Maximum.....	8.90	-----	22.80	24.70	15.40	30.30
Average.....	8.10	7.50	22.80	20.30	11.50	29.80
Summary of all analyses:						
Minimum.....	8	2.89	13.62	17.60	7.58	10.40
Maximum.....	17.51	8	29.70	32.40	36.70	29.34
Average (25 analyses).....	9.92	4.74	19.38	22.57	23.94	19.45

MISCELLANEOUS CHEMICAL STUDIES.

Proteids of cotton seed.—T. B. Osborne and C. L. Voorhees have reported¹ an exhaustive study of these substances. The cotton seed used was freed of the husk and the fat removed with benzin. It was then extracted with water, with 10 and 20 per cent sodium chlorid solution and with 0.2 per cent potash water. The results were not altogether satisfactory to the authors, unusual difficulties being encountered in filtering the extracts and in separating the coloring matters. With brine a globulin was extracted agreeing in composition and in general properties with the vitellin obtained from the seeds of wheat, maize, hemp, castor bean, squash, and flax, to which the name edestin is given. The largest amount of this found in the oil-free meal was 15.83 per cent, and it contained 42.3 per cent of the total nitrogen in the meal.

The proteid matter dissolved by water consisted almost wholly of proteose, amounting to about 0.75 per cent of the oil-free meal. The potash extract contained so much gummy matter that it was filtered with difficulty, and no preparation was made. The nitrogen in the extract represented 44.3 per cent of the total amount in the meal. The residue from the extraction with potash water contained nitrogen equivalent to 11.4 per cent of the total amount in the meal.

Sugar in cotton seed.—The investigations of Ritthausen² and Böhm³ showed the presence in cotton seed of considerable amounts of sugar. By extraction of fine-ground cotton-seed cake with warm 80 per cent

¹ Connecticut State Sta. Rpt. 1893, pp. 211-217.

² Jour. prak. Chem., 29 (1884), p. 351.

³ Sitzber. Ges. Beford. ges. Naturwissensch., Marburg, 1883, No. 1, p. 24; Jour. prak. Chem., 30 (1884), p. 37.

alcohol, the former obtained about 3 per cent of crystallizable material. A study of the physical and chemical properties of this substance led to the conclusion that it was identical with the melitose of Berthelot,¹ a substance which had hitherto been obtained only from eucalyptus manna.² Böhm proposed the name gossypose for the cotton-seed sugar, and both he and Ritthausen evidently considered it a simple and definite compound.

More recent investigations, however, by Berthelot³ have tended to show that the melitose of both eucalyptus manna and of cotton seed is a combination⁴ of raffinose and an amorphous unfermentable substance to which Berthelot gave the name eucalyn. These conclusions regarding the compound nature of melitose have been confirmed by the investigations of Tollens and Rischbiet.⁵

Nitrogen bases of cotton seed.—In further investigations of the constituents of cotton seed, Ritthausen and F. Weger⁶ found that "the mother liquid of melitose from cotton seed dissolved in 90 per cent spirits gave on the addition of PtCl_4 a crystalline precipitate," which was found to be a compound of betain, but it appears doubtful whether betain "exists as such in the seed, or whether it is created by the decomposing influences of acids during the different evaporations." Cholin was also obtained from cotton seed by Böhm.⁷

M. Maxwell,⁸ in continuation of work by Böhm on cholin, of Ritthausen and Weger on betain, and of Gaetgens on the toxic properties of neurin,⁹ undertook to determine the extent to which cholin and betain are present in cotton seed or cotton-seed meal. In a sample of cotton-seed meal he found the following relative proportions: Cholin, 17.5 per cent; betain, 82.5 per cent. The behavior of these substances toward different chemical reagents is described.

COTTON-SEED PRODUCTS.

Cotton seed furnishes a variety of valuable commercial products. The following diagram (p. 97), prepared by Grimshaw¹⁰ on the basis of the actual results at oil mills, indicates how a ton of cotton seed is utilized.

¹ Ann. Chim. et Phys., ser. 3, 46 (1856), p. 66.

² See Thomson, Organic Chemistry of Vegetables, 1842; Mudie, Jour. Pharm., ser. 2, 18 (1832), p. 705; F. von Müller, Eucalyptographia, London and Melbourne, 1885, 10th decade, Eucalyptus viminalis; and especially Johnston, Lond. Ebinb. and Dubl. Phil. Mag., 23 (1843), p. 14; Jour. prakt. Chem., 29 (1843), p. 485.

³ Compt. Rend., 103 (1886), p. 533.

⁴ Scheibler, in Ber. deut. chem. Ges., 22 (1889), p. 3121, states that the so-called eucalyn is merely an impurity and inversion product.

⁵ Liebig's Ann., 232 (1885), pp. 169, 172; Ber. deut. chem. Ges., 18 (1885), p. 26.

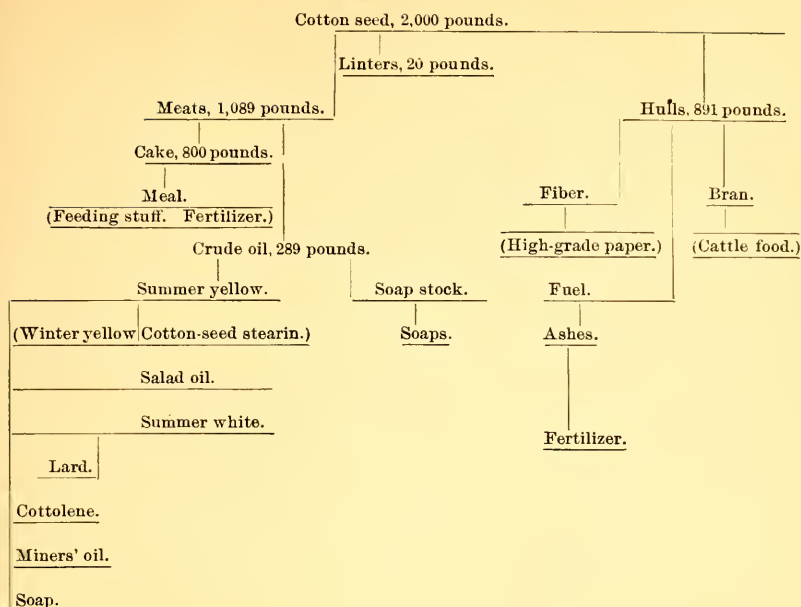
⁶ Jour. prakt. Chem., 30 (1884), p. 32.

⁷ Address before the Scientific Society of Marburg, 1881.

⁸ Amer. Chem. Jour., 13 (1891), p. 469.

⁹ Dorpat. med. Ztschr., 1 (1870), p. 161.

¹⁰ Jour. Frank. Inst., 1889, p. 191.

Products from a ton of cotton seed.

The above diagram was prepared several years ago. Recently the processes of manufacture have been so improved that over 300 pounds (40 to 45 gallons) of oil can be obtained from each ton of seed, and delinting machines have been introduced which remove a much larger amount of linters than is given in this diagram, the proportion of hulls being correspondingly reduced.

COTTON-SEED HULLS.

Cotton-seed hulls, as we have already seen, constitute 45.78 per cent by weight of the ginned seed. They constitute the hard, outer covering of the seed and are composed principally of woody matter arranged, according to Gebek,¹ in five layers of cells. Gebek gives a description of the appearance of a section of cotton-seed hull under the microscope, and refers to a detailed discussion of this material by Bretfeld.²

The table of analyses on page 98 shows that the hulls are principally crude fiber and nitrogen-free extract, these with water constituting more than 90 per cent of the entire substance.

Fertilizing constituents.—In the next table will be found a summary of the results of 8 analyses of the mineral matter of cotton-seed hulls.

¹Landw. Vers. Stat., 42 (1893), p. 279.

²Jour. Landw., 1887, p. 29.

Fertilizing constituents of cotton-seed hulls.

	Water.	Ash.	Nitro- gen.	Phos- phoric acid.	Pot- ash.	Soda.	Lime.	Mag- nesia.	Sul- phuric acid.	Ferric oxid.	Insol- uble mat- ter.
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Minimum	8.76	2.07	0.35	0.09	0.36	0.01	0.13	0.16	0.08	0.02	0.01
Maximum	11.45	2.99	.96	.56	1.32	.02	1.09	.35	.09	.04	.11
Average	10.17	2.40	.69	.25	1.02	.02	.18	.26	.08	.03	.05

Cotton-hull ashes.—The cotton-seed oil mills have in the past largely used the hulls for fuel, the ashes thus produced having been extensively used as a fertilizer.

The quality of these ashes varies greatly on account of impurities introduced, principally by the use of other fuel with the hulls. The table below gives the minimum, maximum, and average composition of cotton-hull ashes compiled from 185 analyses:

Fertilizing constituents in cotton-hull ashes.

	Water.	Phos- phoric acid.	Pot- ash.	Soda.	Lime.	Mag- nesia.	Sul- phuric acid.	Ferric oxid.	Car- bonic acid.	Chlo- rin.	Insol- uble mat- ter.
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Minimum	0.25	2.37	7.02	1.30	0.86	2.85	2.41	0.92	9.56	0.21	0.96
Maximum	22.30	15.37	44.72	3.86	19.35	17.15	2.71	4.93	11.59	3	43.30
Average	9	9.08	23.40	2.58	8.85	9.97	2.56	2.07	10.57	1.60	14.04

Proximate constituents.—In the following table will be found a summary of the results of 22 proximate analyses of the hulls:

Proximate constituents of cotton hulls.

	Water.	Ash.	Protein.	Fiber.	Nitrogen- free extract.	Fat.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Minimum	7.25	1.65	2.78	35.75	12.41	0.75
Maximum	16.73	4.43	5.37	66.95	41.24	5.41
Average	11.36	2.73	4.18	45.32	34.19	2.22

COTTON-SEED BRAN AND COTTON-SEED FEED.

Cotton-seed bran and cotton-seed feed are products very similar to cotton-seed hulls. In fact, cotton-seed feed is a mixture of cotton-seed hulls and cotton-seed meal ground together. Cotton-seed bran usually consists of ground hulls, together with an admixture of meats derived for the most part from the waste of cotton-seed oil mills, the waste consisting principally of immature or frosted seed.

The following table gives a summary of the results of 8 proximate analyses of these two products grouped together:

Proximate constituents of cotton-seed bran and feed.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Minimum	8.86	2.18	6.37	21.39	30.67	1.33
Maximum	13.07	4.92	24.13	43.28	47.33	5.47
Average	11.66	3.06	12.01	30.99	39.22	3.06

COTTON-SEED KERNELS.

By cotton-seed kernels we mean the inner portion of the seed, variously called kernels, meats, hulled seed, or peeled seed.

Fertilizing constituents.—There are apparently but few analyses of the mineral constituents of the kernels. Calvert¹ reports a partial analysis. One hundred parts of the kernels gave 3.52 per cent of ash, containing—

	<i>Per cent.</i>
Phosphate of magnesia	0.652
Phosphate of iron .....	.053
Alkaline phosphate .....	.387
Other salts	2.428

The author states that the kernels contain phosphoric acid in both the soluble and insoluble forms.

The North Carolina Station has reported² a more complete analysis of the mineral constituents of the kernels, as follows:

Fertilizing constituents in cotton-seed kernels.

	<i>Per cent.</i>
Moisture	6.27
Crude ash	4.03
Nitrogen	4.98
Phosphoric acid	1.73
Potash	1.14
Lime .....	.16
Magnesia .....	.78
Ferric oxid .....	.03
Sulphuric acid .....	.12
Chlorin .....	.01
Silicic acid .....	.05

These two analyses apparently constitute the analytical data for mineral matter of cotton-seed kernels.

¹ Compt. Rend., 65 (1867), p. 1150; Jour. prakt. Chem., 1869, II, p. 122.

² North Carolina Sta. Rpt. 1882, p. 97.

Proximate constituents.—The table below gives the results of 7 proximate analyses of this product:

Proximate constituents of cotton-seed kernels.

No.		Date of analysis.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per ct.</i>
1	Character of seed unknown.	1856	6.57	8.91	31.86	7.30	14.82	31.28
2	Egyptian seed	1870	7.54	8.60	27.20	32.71		23.95
3	American seed	1870	8.12	9.44	28.12	33.74		20.58
4	Egyptian seed		7.90	5.00	29.40	1.90	17.96	37.84
	Average		7.53	7.99	29.14	4.68	26.33	24.33
5	Character of seed unknown.	1870	6.14	7.02	33.57	7.16	9.11	37.00
6	Kernels of cotton seed	1882	6.27	4.03	29.25	4.38	19.52	36.55
7	Kernels of cotton seed	1889	6.04	5.41	33.06	3.09	15.81	36.59
	7 analyses { Minimum		6.04	4.03	27.20	1.90	9.11	20.58
	{ Maximum		8.12	9.44	33.57	7.30	19.52	37.84
	{ Average		6.94	6.92	30.35	4.76	21.39	29.64

COTTON-SEED CAKE.

Renouard ¹ states that in 1881 three kinds of cotton-seed cake were recognized in France: (1) Linty (*cotonneaux*), (2) crude (*brut*), and (3) refined (*épuré*).

The linty cake, so called because it contains much waste cotton, is used only for manure. Its color is dark brown. The better grades of this cake are distinguished as cotton from Catania, the poorer kinds as cotton from Syria. The average composition of these is as follows:

Composition of Catanian and Syrian cotton cake.

	Catanian.	Syrian.
	<i>Per cent.</i>	<i>Per cent.</i>
Water	8.40	7.40
Oil	5.20	6.92
Organic matter	79.81	80.33
Ash	6.59	5.28
	100	100
Nitrogen	3.23	2.86
Phosphoric acid	2.02	1.12

The crude cake possesses, when fresh, a greenish color, which on storage passes over to a brown. It contains large quantities of hard, black fragments of the hulls. Its nitrogen content is higher than that of the linty variety. It is used exclusively as a cattle food. In trade it is usually distinguished as cotton from the Levant or Alexandria. Its composition is as follows: Water, 10.98 per cent; oil, 6.09; organic substance, 77.03; ash, 6; nitrogen, 4.03, and phosphoric acid, 2.07.

The refined cotton seed cake, manufactured chiefly in Marseilles, is distinguished from the former kinds by its lack of coarse fragments of

¹ Ann. Agron., 7 (1881), p. 511.

hulls. It is of a yellowish color, broken by numerous dark streaks. It contains water, 11.26 per cent; oil, 4.80; organic substance, 78.76; ash, 5.28; nitrogen, 4.43; and phosphoric acid, 1.96.

In this country only two kinds of cake are recognized—(1) undecorticated cotton-seed cake, made from the whole seed without removal of the hull, and (2) decorticated cotton-seed cake, which is simply the unground cake from the manufacture of cotton oil. The former is not manufactured to any extent in this country at the present time.

Undecorticated cotton-seed cake.—The maximum, minimum, and average proximate composition of undecorticated cake, compiled from all available analyses, is shown in the following table, together with the summaries published by Dietrich and König, Wolff, and Kühn:

Proximate composition of undecorticated cotton-seed cake.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Dietrich and König's summary (46 analyses):						
Minimum	7.55	5.03	13.70	5.29	24.20	3.46
Maximum	14.50	12.51	33.69	25.59	56.78	9.02
Average	11.86	6.38	24.25	20.95	30.74	5.82
Wolff's summary:						
Cotton-seed meal	10.60	7.20	24.70	24.90	26	6.60
Cotton-seed meal, cleaned	9.80	6.80	28.30	18.40	29	7.70
Kühn's summary:						
Minimum	6.60	-----	18.20	17	26.50	5.10
Maximum	14.20	-----	28.30	27	36.70	9.80
Average	10	6.80	23.50	21.10	32	6.60
Summary of all analyses (62):						
Minimum	7.55	4.33	13.70	5.29	24.20	3.20
Maximum	14.50	12.51	33.69	27.17	56.78	9.02
Average	11.64	6.26	24.08	20.68	31.43	5.91

Decorticated cotton-seed cake.—This product in the form of cake finds its principal uses in England or on the continent of Europe, very little being used in America, where it is always ground to cotton-seed meal. In composition it is, of course, practically the same as cotton-seed meal.

The maximum, minimum, and average composition of this material is given by Dietrich and König, Wolff, and Kühn as follows:

Proximate composition of decorticated cotton-seed cake.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Dietrich and König's summary (429 analyses):						
Minimum	6.25	4.15	34.71	2.14	13.15	7.14
Maximum	15.60	10.08	50.80	9.80	28.71	21.05
Average of all analyses	8.62	7.05	44.09	5.16	20.85	14.23
Average (28 analyses), 1870-1879	8.76	7.29	44.24	6.27	19.62	13.82
Average (401 analyses), 1885 to date	8.61	7	44.09	4.93	21.12	14.25
Average of all analyses (429)	8.62	7.05	44.09	5.16	20.85	14.23
Wolff's average	8.90	7.20	43.60	5.70	19.70	14.90
Kühn's summary:						
Minimum	7.70	-----	19.70	5.40	10.50	5.40
Maximum	14.30	-----	43.80	11.40	27.40	19.70
Average	10	7.90	40.90	9	15.80	16.40

COTTON-SEED MEAL.

Fertilizing constituents.—The following table gives the maximum, minimum, and average composition of cotton-seed meal with regard to fertilizing constituents as compiled from 204 analyses:

Fertilizing constituents in cotton-seed meal.

	Water.	Ash.	Nitro- gen.	Phos- phoric acid	Pot- ash.	Soda.	Lime.	Mag- nesia.	Sul- phuric acid.	Ferrie oxid.	Insol- uble mat- ter.
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>P. ct.</i>
Minimum	4.34	3.35	3.23	1.26	0.87	0.03	0.27	0.48	0.07	0.12	0.02
Maximum	12.57	9.90	8.08	4.62	3.32	.73	1.25	1.26	.40	.19	1.36
Average	7.81	6.95	6.79	2.88	1.77	.29	.43	.95	.19	.14	.27

Investigations by Kilgore and Noble¹ have shown that 85.5 per cent of the potash in cotton-seed meal is soluble in water, but that only 2.65 per cent of the phosphoric acid is available, and that ordinary methods of wet combustion for preparing solutions for determination of phosphoric acid in this material are not reliable.

M. B. Hardin,² in a paper "On the occurrence of metaphosphoric acid and pyrophosphoric acid in cotton-seed meal," after describing various tests and methods of estimation, says:

All the reactions seem to show, beyond any reasonable doubt, the presence of both metaphosphoric and pyrophosphoric acid in the aqueous solution of the meals examined. While no quantitative determinations were attempted, the qualitative results indicated more metaphosphoric than either pyrophosphoric or orthophosphoric acid. Whether pyrophosphoric and metaphosphoric acid exist in cotton seed or are formed during the preparation of the meal is a point worth investigating.

The phosphoric acid in 11 analyses was as follows: Total phosphoric acid, 2.65; insoluble, 0.16; soluble, 1.66; reverted, 0.83; available, 2.49.

Proximate constituents.—The following table shows the maximum, minimum, and average composition of cotton-seed meal as compiled from over 400 proximate analyses:

Proximate constituents of cotton-seed meal.

	Water.	Ash.	Protein.	Fiber.	Nitrogen- free extract.	Fat.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Minimum	5.29	1.72	23.27	1.88	9.13	2.18
Maximum	18.52	10.62	52.88	15.15	38.68	20.66
Average	8.52	7.02	43.26	5.44	22.31	13.45

COTTON-SEED OIL.³

In the early history of cotton in this country the seed was a refuse, which was either burned or thrown away. Its products are now among

¹North Carolina Sta. Bul. 91d.

²South Carolina Sta. Bul. 8 (n. ser.).

³See also article on handling and uses of cotton, p. 365.

the most important elements in our national industry. The oil is of course the main product.

By far the larger portion of the oil manufactured in this country is used in the preparation of food products, principally refined lard and salad and cooking oils. It is also used in the manufacture of soaps of various kinds, washing powder, cosmetics, to some extent as a lubricant (when refined) and for illuminating purposes, in the manufacture of bolts, nuts, etc.; and generally as a substitute for olive oil.

The tables of analyses given on a previous page show that the whole cotton seed contains on an average from 20 to 25 per cent of crude oil (soluble in ether), the Egyptian seed being somewhat richer in this respect than the American. A ton of American cotton seed contains on the average about 50 gallons of oil, but the oil mills have thus far not been able to secure more than 45 gallons per ton. Egyptian seed yield slightly more oil, but it is stated to be of somewhat poorer quality.

The crude oil from the presses contains, among other impurities, a peculiar coloring matter, which gives it a ruby-red color, sometimes so intense as to cause the oil to appear nearly black. This coloring matter, together with a large proportion of the other impurities ("mucilage") is removed by the process of refining.

In this process the impurities in suspension are often allowed to settle and the clear supernatant oil is drawn off. To the latter from 10 to 15 per cent of caustic soda (10° to 28° Baumé), according to the nature of the oil, is added and the mixture agitated at a temperature of 100° to 110° F. for 45 minutes, the precipitate being allowed to settle from 6 to 36 hours. The residues obtained are disposed of as soap stock, in the manufacture of stearin, etc.

The yellow oil resulting from this process is further purified by being heated and allowed to settle again, or by filtration, and is called summer yellow oil. Winter yellow oil is made from the above material by chilling it until it partially crystallizes and separating the stearin formed (about 25 per cent) in presses similar to those used for lard.¹

The latter constitutes the true cotton-seed stearin of commerce and is largely used in the preparation of butter and lard surrogates and candles.

Another substance, improperly called cotton-seed stearin, is obtained by distilling with superheated steam the mixture of organic acids formed when a mineral acid is made to decompose the "foots" obtained during the process of refining cotton-seed oil by alkalis, and pressing out the "olein" from the distillate after cooling and solidification.²

For the preparation of the white oil of commerce the yellow oil obtained as above is shaken up with 2 to 3 per cent of fuller's earth and filtered.

¹ H. W. Wiley: U. S. Dept. Agr., Division of Chemistry Bul. 13, p. 412.

² A. Wright: Oils, Fats, Waxes, and their Manufactured Products, p. 305.

Physical properties of the oil.—Cotton-seed oil is twenty to thirty times less fluid than water. The refined oil is of a straw or golden-yellow color, or occasionally nearly colorless, and when properly prepared it is of a pleasant taste.

Specific gravity: According to Allen¹ the specific gravity of the crude oil varies from 0.928 to 0.930, of the refined oil from 0.922 to 0.926 at 15° to 15.5° C. Wiley,² in examinations of 19 samples of refined oil, found specific gravities ranging from 0.9132 to 0.9154, with a mean of 0.9142 at 35° C. Wiley also reports determinations of specific gravity at 90 different temperatures (10°–100° C.), showing a variation of from 0.9249 at the lowest temperature to 0.8683 at the highest temperature. Allen gives comparative determinations in which the specific gravity was found to be 0.9250 at 15.5° and 0.8725 at 98°–99° C., with a mean variation of 0.00063 for each degree of temperature. Muter³ gives the specific gravity of brown oil as 0.9176, of refined oil 0.9136 at 100° F. (37.8° C.). Sutton⁴ places the specific gravity of cotton-seed oil at from 0.9225 to 0.9236 at 15.5° C. and 0.8684 at 99° C. Brannt⁵ gives the specific gravity of the oil as follows: Crude oil at 68° F. (20° C.), 0.9283; at 59° F. (15° C.), 0.9306; at 50° F. (10° C.), 0.9343; refined oil, 0.9264 at 59° F. J. H. Long,⁶ in an examination of 2 samples of crude oil and of 4 samples of oil refined by different processes, obtained the following variations: Crude oil (1) 0.9325 at 3° C. to 0.9030 at 46.5°, (2) 0.9290 at 4.8° C. to 0.8994 at 49.6°; refined oil (1) 0.9291 at 4.5° C. to 0.9014 at 45.4°, (2) 0.9312 at 2° C. to 0.9006 at 47°, (3) 0.9295 at 3.8° C. to 0.9000 at 47.4°, and (4) 0.9322 at 0.7° C. to 0.9013 at 46.5°. "The decrease in specific gravity at mean temperatures varies in the different samples between 0.00066 and 0.00068 * * * for each degree."

Solidifying point: Brannt states the solidifying point of crude oil to be 27° to 28.5° F. (—2.8° to —2° C.), refined oil 30° to 32° F. (—1.1° to 0° C.); Allen, 1° to 4° C.; Wiley, "near or below freezing;" and Muter, 34° F. (1° C.).

Refractive index: The mean refractive index of refined oil, as shown by an Abbe refractometer, was found by Wiley to be 1.4674 at 25° C. The variation in the refractive index is stated to be inversely as the temperature, the mean rate of variation for each degree being 0.000288. Long (vide supra), with the method of minimum deviation, using a Meyerstein spectrometer and hollow prism, obtained the following results: Crude oil, 1.4694 at 27.9° C. to 1.4624 at 46.2°; refined oil (1), 1.4744 at 19.3° C. to 1.4658 at 44.2°, (2) 1.4736 at 18.3° C. to 1.4650 at 40.2°, (3) 1.4755 at 13.8° C. to 1.4660 at 39.2°, (4) 1.4742 at 19.3° C. to

¹ Commercial Organic Analysis, Vol. II, p. 112.

² U. S. Dept. Agr., Division of Chemistry Bul. 13, p. 418.

³ Spon's Encyclopedia, II, p. 1470.

⁴ Volumetric Analysis, p. 344.

⁵ Animal and Vegetable Fats and Oils, etc., p. 235.

⁶ Amer. Chem. Jour., 10 (1888), p. 395.

1.4672 at 36.8°. The decrease in refractive index was something less than 0.0004 for each degree of rise in temperature, and was not very different from that found for olive oil by the same analyst.

Crystallization and melting points of fatty acids: The crystallization point was found by Wiley to vary from 30.5° to 35.6°, with a mean of 33.5° C.; the melting point from 34.6° to 44.4°, with a mean of 39.1°. Allen gives the following figures by Hübl: Solidifying point, 30.5° C.; melting point, 37.7°. The high solidifying point of the fatty acids of cotton oil sharply distinguishes it from the true drying oils. The fatty acids of linseed oil solidify at 13.3° C.

Rise of temperature with sulphuric acid: This varies, according to Wiley, from 80.4° to 90.2° C., with a mean of 85.4° C.

Color with sulphuric acid: The colors produced by concentrated sulphuric acid are with crude oil very bright red before stirring, dark red to nearly black after stirring; with refined oil reddish brown before stirring, dark reddish brown after stirring. Wiley observed that with refined oil the color varied from deep reddish brown to almost black.

Chemical properties.—Cotton oil and oils of similar character are classed by Allen in the "cotton-seed oil group." This group is intermediate between the olive oil, or nondrying group, and the linseed oil, or drying group, since the oils of this class undergo more or less drying on exposure to air. As regards drying properties, the more important vegetable drying oils stand in the following order: Linseed oil, cotton oil, rape oil, peanut oil, and olive oil. According to Braunt,¹ pure cotton-seed oil consists principally of palmitin and olein, palmitin being separated at 12° C. Gebek² states that the pure fat of cotton seed consists almost entirely of palmitin, linolein, and olein, and is for the most part neutral. The presence of a small amount of linoleic acid explains the moderate drying quality of this oil.

The amount of glycerol produced by saponification of the oil is reported by Allen to be 9.5 per cent.

In investigations by Stellwaag³ 4.35 per cent of lecithin was found in the ether extract and 1.52 per cent in the benzin extract of cotton-seed meal.

Cotton oil properly prepared is generally neutral, but Allen states that "cotton-seed oil expressed in England from decorticated seed often contains so large a proportion of free acid that purification with alkali becomes practically impossible." He found that a sample of oil expressed from the decorticated seed in Liverpool "required 14.1 per cent KOH to neutralize free acid." Stellwaag found in the ether extract of cotton-seed meal 3.24 per cent of free fatty acids and 92.89 per cent of neutral fat, and in the benzin extract 16.31 per cent of free fatty acids and 80.98 per cent of neutral fat. The amount of free fatty acids would probably

¹ Animal and Vegetable Fats and Oils, etc., p. 236.

² Landw. Vers. Stat., 42 (1893), p. 278.

³ Landw. Vers. Stat., 37 (1890), p. 148.

be determined largely by the age and state of preservation of the samples of oil or meal examined, although Reitnair has observed that cotton seed meal kept for several months in a warm laboratory showed no change as far as the saponification equivalent and iodine number of the ether extract indicated.

Gebek found 0.058 per cent of phosphorus in the ether extract of cotton-seed meal.

Saponification value: The results reported by Allen show the saponification value of cotton oil to vary from 190.8 to 196.8, while Wiley's average is 197.7. Wright¹ gives 195 as an average. These figures indicate a close relationship between cotton oil and the vegetable drying oils, for which the saponification value varies from 187 to 196.2, a relationship which is further confirmed by the iodine numbers reported below. Stellwaag, in the investigation already referred to, found the saponification value of the ether extract of cotton-seed meal to be 194, of the benzine extract 196.4.

Iodine number: Cotton oil possesses in a high degree the property of absorbing iodine. "This is due not only to the large percentage of oleic acid which it contains, but also probably to the presence of a small amount of linoleic acid or some homologue thereof. In the samples examined in no case did the iodine number fall below 100, and in one instance it rose to 116.97. The mean iodine number was 109.02."²

The limits given by Allen, as shown by the work of a number of analysts, are 105 to 109. Wright gives 105 to 108, with an average of 106; Schädler, 106-107; and Benedikt and Lewkowitsch,³ collating from a number of sources, 102 to 117. Holde⁴ in investigation of the accuracy of Hübl's method found iodine numbers varying from 110 to 115, the higher figures obtained being ascribed to more complete saturation of the oil with iodine by the improved method used. In studying the ether extract of cotton-seed meal Gebek⁵ found, as Reitnair had pointed out, that the iodine number varied with the purity of the extract. The extract with ordinary ether from air-dry material showed an iodine number of 96.5, while for purer extracts the iodine number was 100.8 to 102.2. The iodine numbers of the fatty acids of the oil are given by different authorities as follows: Schädler, 112 to 115; Moranski and Demski, 110.9 to 111.2; and Williams, 115.7.

Reaction with silver nitrate: Another important property of cotton oil is its power of reducing silver to the metallic state under certain conditions. A test based upon this property, first proposed by Bechi and since modified by various analysts,⁶ may be applied either to the oil

¹ Fats, Oils, Waxes, and Their Manufactured Products, p. 181.

² Wiley, *loc. cit.*

³ Oils, Fats, and Waxes, p. 306.

⁴ Mitt. königl. tech. Versuchs., Berlin, 1891, 9, p. 81.

⁵ Landw. Vers. Stat., 42 (1893), p. 287.

⁶ Analyst, 1887, p. 170; 1888, pp. 98, 161.

itself or to its fatty acids. The silver either forms a metallic mirror on the sides of the vessel or is reduced in the form of minute black particles, which give a brown or black appearance, and in some cases a greenish tint, to the liquid.

Cotton-seed stearin: The process by which the two products which pass under this name in commerce are made have been briefly described on page 103. Brannt states that the fat separated from cotton oil by chilling (to 43° to 54° F.) and pressure is palmitin. The melting point of the stearin varies somewhat with the extent of pressure, but it is generally pressed so that it will melt above 30° C. Allen reports the following figures obtained in an examination of the substance: Melting point, 32° C.; specific gravity at 98° to 99° C., 0.866; saponification equivalent, 285 to 294. According to Allen, by far the greater part of the "cotton-seed stearin" of commerce is simply the product obtained by the distillation of "foots," as noted on page 103. "Products of this kind appear to contain a large amount of unsaturated solid fatty acids, possibly isoleic acid. A. H. Allen found that a 'stearin' of this kind had the specific gravity 0.868 at 99° and melted at 40° , while the iodine number was 89.9; the theoretical value for pure isoleic (oleic) acid being 90.1."¹

Coloring matter in cotton oil: Crude cotton-seed oil contains about 1 per cent of a peculiar coloring matter, referred to above, which is separated in the process of refining. When crude cotton oil is saponified and the resultant soap exposed to the air a fine purple or violet-blue coloration rapidly appears. This is the so-called "cotton-seed blue" which, according to Kuhlman, has the composition $C_{17}H_{24}O_4$. "It is amorphous; readily destroyed by oxidizing agents; insoluble in water, diluted acids, and alkalis; sparingly soluble in carbon disulphid and chloroform, but more readily soluble in alcohol and in ether; and dissolves with purple color in strong sulphuric acid."² According to Brannt, the unoxidized coloring matter of the oil is insoluble in acids, slightly soluble in water, and freely soluble in alcohol or alkalis. In its dry state it is a light powder of pungent odor, brown color, and is strongly tinctorial. According to J. Longmore, quoted by Allen, it is of a golden-yellow color, insoluble in water, and "dyes well and perfectly fast on both wool and silk." Under the name of gossypin it is used as a coloring matter in the industries. It is stated, however, by Gebek,³ who studied this substance, that it does not make a permanent color when used as a dye.

TABLES OF ANALYSES.

In the following tables, unless otherwise stated, the figures refer to upland cotton. These analyses have been gathered from many

¹ Wright, *loc. cit.*

² Allen, *loc. cit.*

³ Landw. Vers. Stat., 42 (1893), p. 287

different sources, and where the number of analyses is large their average must represent very accurately the true composition of the substance in question. This is particularly true in the case of the seed products, where we have grouped a comparatively large number of analyses. In the case of the leaves, stem, roots, and bolls, where the composition seems to depend largely on maturity of the plant, the average means very little, and a great number of analyses will of course be necessary to determine with accuracy the composition of these products at different stages of growth. We have, however, inserted the average in all tables in the latter cases, as much for the sake of uniformity as for what the figures show. It may be well to state here that in many proximate analyses the proportion of water was not given. When this was the case we have, for the sake of uniformity, assumed 10 per cent of water and calculated the analyses accordingly, the fact being stated in footnotes. Again, in several cases the analyses have failed to add to 100. In this case, when the difference from 100 was 0.5 per cent or less, correction was made in the nitrogen-free extract and the analysis included in the average. Where the error was greater than 0.5 the fact has been noted by inclosing the analyses in (), and the analysis excluded from the average.

It has not seemed desirable to give more than the maximum, minimum, and average composition of cotton-hull ashes. A large number of analyses of this product are on record (185 having been compiled for the purposes of this article), but as a result of the conditions under which it is produced it is very variable in composition and individual analyses would be of little value in a discussion of the chemistry of cotton.

Fertilizing constituents of the cotton plant—Continued.

No.	Date of analysis.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.	Soda.	Lime.	Magnesia.	Ferric oxid.	Sulphuric acid.	Chlorine.	Insoluble matter.	References and remarks.	No.
ENTIRE PLANT—continued.															
Plants grown on fertile soil—Continued.															
24	With nitrogen and potash—														
25	Flowering stage	<i>P. et.</i>		<i>P. et.</i>	<i>P. et.</i>	<i>P. et.</i>	<i>P. et.</i>	<i>P. et.</i>	<i>P. et.</i>	<i>P. et.</i>	<i>P. et.</i>	<i>P. et.</i>	<i>P. et.</i>	J. T. Anderson, Alabama College Sta. Bul. 57.	24
	Bolling stage			3.83	.81	2.98								do.	25
	With nitrogen and phosphoric acid—			2.44	.74	2.03									
26	Flowering stage			4.23	.85	3.20								do.	26
27	Bolling stage			2.06	.69	1.49								J. B. McBryde, Tennessee Sta. Bul. 5.	27
	With potash and phosphoric acid—														
28	Flowering stage			3.87	.80	3.10								do.	28
29	Bolling stage			2.44	.90	2.75								do.	29
	With nitrogen, potash, and phosphoric acid—														
30	Flowering stage			4.35	.86	3.61								do.	30
31	Bolling stage			2.34	.70	3.05								do.	31
	Average for plants in flowering stage.			3.80	.84	2.79									
	Average for plants in bolling stage.			2.12	.66	2.15									
32	Mature plants		4.57	—	—	—	1.17	0.82	0.46	—	0.17	0.04	0.10	C. T. Jackson, U. S. Pat. Office Rpt. 1857, p. 298.	32
33	do		6.27	1.57	.47	1.43	0.11	1.53	.56	—	.22	—	.47	J. B. McBryde, Tennessee Sta. Bul., vol. 4, No. 5.	33
34	Young plants collected June 3.		15.62	3.44	3.16	2.42	.48	4.80	1.15	0.25	1.24	—	1.31	W. L. Hutchinson and L. G. Patterson, Mississippi Sta. Tech. Bul. 1.	34
35	Young plants collected June 23		14.58	3.54	1.89	1.76	.42	4.23	1.04	.36	.90	—	2.08	do.	35
	Minimum		4.57	1.57	.35	1.05	.11	.82	.46	.25	.17	—	.10		
	Maximum		15.62	4.35	3.16	3.61	.48	4.80	1.15	.36	1.24	—	2.08		
	Average		10.26	3.17	.86	2.48	.33	2.84	.80	.30	.63	—	—		
ROOTS.															
1	Of mature plants		6.10	1.39	.37	1.15	.62	1.09	.40	.34	.24	.40	.54	Georgia Dept. Agr. Rpt. 1886, p. 333. Analysis by Ville.	1
2	do		5.08	1.17	.38	1.19	.54	1.18	.42	.35	.21	.41	.44	H. C. White, Proc. Georgia State Agt. Soc., 1874, p. 45.	2
3	do		7.65	3.31	.71	.86	.16	.70	.34	—	.13	—	.21	J. B. McBryde, Tennessee Sta. Bul., vol. 4, No. 5.	3
4	do		6.98	3.36	.59	1.34	.13	.39	.30	—	.10	—	.23	do	4
5	Collected July 2.		6.52	1.13	.68	1.69	.05	1.03	.59	.25	.25	—	.77	Hutchinson and Patterson, Mississippi Sta. Tech. Bul. 1.	5

6	Collected July 12	1890	4.87	1.07	57	1.28	.85	.55	.18	.29	.40	.....	.....
7	Collected Aug 1	1890	4.18	.91	.36	.99	.35	.51	.13	.16	.23	.....	.....
8	Collected Aug 1	1890	6.54	1.15	.92	1.30	.41	.91	.81	.30	.41	.....	.....
9	Collected Aug 11	1890	4.04	.94	.55	.90	.15	.76	.49	.13	.31	.....	.....
10	Collected Aug 22	1890	3.91	.92	.31	.70	.07	.49	.34	.10	.16	.....	.....
11	Collected Aug 28	1891	7.23	1.58	.66	3.10	.11	.69	.56	.31	.27	.....	.....
12	Collected June 18	1891	4.78	.96	.00	1.89	.12	.48	.42	.18	.18	.....	.....
13	Collected June 28	1891	4.18	.86	.58	1.48	.09	.43	.39	.19	.36	.....	.....
14	Collected July 8	1891	4.25	.97	.59	1.57	.07	.40	.41	.11	.31	.....	.....
15	Collected July 18	1891	3.29	.57	.50	.94	.08	.36	.35	.13	.34	.....	.....
16	Collected Aug 7	1891	3.48	.71	.47	.95	.08	.36	.31	.09	.72	.....	.....
17	Collected Aug 17	1891	3.21	.52	.45	1.03	.06	.43	.26	.21	.37	.....	.....
18	Collected Aug 28	1891	3.54	.47	.49	.71	.13	.42*	.26	.07	1.01	.....	.....
	Minimum	6.93	3.01	.47	.14	.70	.05	.36	.26	.10	.16	.....	.....
	Maximum	10	7.23	1.58	.92	3.10	.62	1.18	.81	.35	1.01	.....	.....
	Average	9.66	4.50	.92	.49	1.28	.19	.64	.41	.22	.40	.....	.....
	STEMS.												
1	Of mature plants	1857	2.34	.....	.26	.26	.31	.58	.10	.....	.06	.11	C. T. Jackson, U. S. Patent Office Rpt. 1857, pp. 296-304. Sea Island cotton from Hancock Co., Miss.
2	do	1874	3.98	1.16	.54	.97	.27	1.05	.39	.06	.22	.28	H. C. White, Proc. Georgia State Agt. Soc., 1874, p. 45. Short staple cotton.
3	do	1852	3.10	.....	1.08	.92	.....	.75	.11	.....	.11	.02	O. Judd, Proc. Amer. Assn. Sci., 1852, p. 219. Johnson, How crops grow.
4	do	.....	4.87	1.31	.44	1.08	.34	1.05	.40	.05	.24	.33	Georgia Dept. Agr. Rpt. 1886, p. 333. Analysis by Vile.
5	do	1889	3.93	.83	.20	.92	.11	1.05	.43	.....	.14	.....	J. B. McBryde, Tennessee Sta. Bul., vol. 4, No. 5. Short staple cotton.
6	do	1890	4.23	.74	.17	1.45	.09	.62	.30	.....	.08	.17	.....
7	Collected July 2	1890	6.63	1.66	.66	1.79	.43	1.48	.68	.06	.20	.04	Hutchinson and Patterson, Mississippi Sta. Tech. Bul. 1.
8	Collected July 12	1890	5.39	1.66	.71	1.18	.63	1.28	.67	.07	.16	.04	.....
9	Collected July 22	1890	6.10	1.59	.51	1.49	.37	1.30	.63	.06	.19	.04	.....
10	Collected Aug 1	1890	5.41	1.60	.47	1.36	.34	1.12	.67	.04	.22	.04	.....
11	Collected Aug 11	1890	3.93	1.03	.51	1	.30	.83	.44	.08	.16	.03	.....
12	Collected Aug 22	1890	2.75	.96	.26	.68	.11	.56	.31	.01	.10	.04	.....
13	Collected June 18	1891	9.64	3.28	1.08	3.91	.14	1.52	.72	.15	.30	.19	.....
14	Collected June 28	1891	6.44	1.76	.78	2.35	.15	1.13	.50	.03	.18	.06	.....
15	Collected July 8	1891	5.31	1.78	.73	1.93	.14	.94	.47	.09	.17	.10	.....
16	Collected July 18	1891	5.22	1.54	.74	1.76	.22	.88	.47	.05	.13	.10	.....
17	Collected July 28	1891	4.44	1.68	.88	1.34	.18	.85	.35	.14	.12	.10	.....
18	Collected Aug 7	1891	4.27	1.63	.67	1.25	.16	.82	.31	.09	.13	.14	.....
19	Collected Aug 17	1891	4.07	1.10	.64	1.43	.11	.73	.22	.08	.09	.09	.....
20	Collected Aug 28	1891	3.92	1	.49	1.01	.18	.83	.22	.15	.13	.22	.....
	Minimum	8.41	2.34	.74	.17	.26	.09	.56	.10	.01	.04	.02	.03
	Maximum	11.71	9.64	3.28	1.08	3.91	.63	1.52	.72	.15	.30	.33	.28
	Average	10.01	4.80	1.46	.59	1.41	.24	.97	.42	.07	.16	.17	.10

a Assumed.

Fertilizing constituents of the cotton plant—Continued.

No.	Date of analysis.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.	Soda.	Lime.	Magnesia.	Ferric oxid.	Sulphuric acid.	Chlorine.	Insoluble matter.	References and remarks.	No.
LEAVES.															
1	Of mature plants	<i>P. et.</i>	17.26	1.41	<i>P. et.</i>	1.03	<i>P. et.</i>	4.52	<i>P. et.</i>	0.86	<i>P. et.</i>	0.60	<i>P. et.</i>	Georgia Dept. Agr. Rpt. 1886, p. 333. Analysis by Ville.	1
2	do	.....	9.33	.....	1.04	1.31	71	2.71	07	.....	.39	.83	.57	C. T. Jackson, U. S. Patent Office Rpt. 1857, p. 298. Sea Island cotton from Hancock Co., Miss.	2
3	do	.....	15.22	2.14	1.18	2.28	1.41	4.28	.93	.85	1.97	.71	1.61	H. C. White, Proc. Georgia State Agl. Soc., 1874, p. 45. Analysis by Ville.	3
4	do	9.50	16.42	2.37	.46	.83	.37	7.08	1.26	.....	.84	.....	.93	J. B. McBryde, Tennessee Sta. Bul., vol. 4, No. 5.	4
5	do	12.14	12.05	2.45	1.08	1.33	.60	4.10	.76	.....	.38	.....	1.20	do	5
6	Collected July 2	1890	13.68	3.80	1.08	2.63	.60	5.28	1.26	.12	.82	.....	.26	Hutchinson and Patterson, Mississippi Sta. Tech. Bul. 1.	6
7	Collected July 12	1890	14.09	3.92	1.06	1.58	1.21	5.31	1.23	.16	.93	.....	.25	do	7
8	Collected July 22	1890	14.99	3.80	.83	1.48	.61	5.63	.99	.27	.94	.....	.44	do	8
9	Collected Aug. 1	1890	15.32	3.65	1.03	1.27	.36	5.27	1.28	.16	1.12	.....	.64	do	9
10	Collected Aug. 11	1890	12.33	3.21	.72	1.21	.23	4.61	.98	.11	.88	.....	.08	do	10
11	Collected Aug. 22	1890	13.08	3.11	1.21	1.65	.22	4.66	1.03	.12	.87	.....	.40	do	11
12	Collected June 18	1891	11.92	4.27	1.06	2.36	.19	3.83	.66	.40	.68	.....	.26	do	12
13	Collected June 28	1891	12.17	3.87	1.45	2.54	.23	3.63	.66	.12	.80	.....	.05	do	13
14	Collected July 8	1891	11.38	3.73	1.54	1.93	.30	3.68	.81	.24	.51	.....	.23	do	14
15	Collected July 18	1891	11.57	3.55	1.76	2.21	.27	3.75	.77	.30	.60	.....	.31	do	15
16	Collected July 28	1891	13.73	3.53	2.08	1.99	.38	4.87	.93	.46	.52	.....	.66	do	16
17	Collected Aug. 7	1891	11.86	3.35	1.69	1.59	.24	3.89	.68	.46	.90	.....	.30	do	17
18	Collected Aug. 17	1891	11.93	3.03	1.57	1.89	.11	3.56	.60	.22	1.47	.....	.45	do	18
19	Collected Aug. 28	1891	10.73	2.67	1.54	1.72	.23	3.67	.82	.23	.87	.....	.45	do	19
	Minimum	9.50	9.33	1.41	.42	.83	.11	2.71	.07	.11	.38	.60	.05		
	Maximum	12.14	17.26	4.27	2.08	2.63	1.41	7.08	1.28	.85	2.04	.83	2.12		
	Average	10.10	13.11	3.21	1.19	1.50	.48	4.44	.87	.31	.92	.71	.59		
BOLLS.															
1	Collected July 22	1890	6.02	3.11	1.13	2.08	.06	.74	.44	.10	.55	.....	.11	do	1
2	Collected Aug. 1	1890	5.71	2.99	1.08	2.14	.37	.61	.45	.05	.51	.....	.10	do	2
3	Collected Aug. 11	1890	5.25	2.53	1.04	2.09	.07	.41	.40	.06	.35	.....	.04	do	3
4	Collected Aug. 22	1890	5.11	3.03	.98	1.93	.21	.51	.41	.07	.35	.....	.10	do	4
5	Collected Aug. 7	1891	3.87	1.87	.82	1.41	.03	.43	.38	.13	.31	.....	.09	do	5
6	Collected Aug. 17	1891	3.43	1.70	.71	1.21	.03	.37	.35	.25	.27	.....	.12	do	6
	Minimum	3.43	3.43	1.70	.71	1.21	.03	.37	.35	.05	.27	.....	.04		
	Maximum	6.02	6.02	3.11	1.13	2.14	.37	.74	.45	.25	.55	.....	.12		
	Average	4.90	4.90	2.54	.96	1.81	.15	.51	.40	.11	.39	.....	.09		

7	Bars.....	1874	12.96	1.03	.89	1.85	1.14	3.54	.79	.66	1.71	.53	1.82	H. C. White, Proc. Georgia State Agl. Soc., 1874, p. 45.	7
8	.....do.....	1880	9.47	1.36	.40	2.90	.05	1.09	.29	.....	.59	.....	.27	J. B. McBryde, Tennessee Sta. Bul., vol. 4, No. 5.	8
9	.....do.....	1890	14.36	.87	.17	3.23	.05	.77	.21	.....	.31	.....	.31	.....do.....	9
	Minimum.....		9.47	.87	.17	1.85	.05	.77	.21	.....	.31	.....	.27		
	Maximum.....		14.36	1.36	.89	3.23	1.14	3.54	.79	.....	1.71	.....	1.82		
	Average.....		11.92	1.08	.48	2.66	.41	1.80	.43	.....	.87	.....	.80		
	LINT.														
1	Sea Island.....		1	.....	.09	.48	.....	.11	.03	.03	.04	.....	.....	F. H. Bowman, Structure of Cotton Fiber, 1881, p. 56. Analysis by Urc.	1
2	Upland.....	1874	1.14	.....	.04	.47	.02	.07	.10	.01	.04	.02	.14	W. J. Land, Southern Cultivator, 32 (1874), p. 339.	2
3	.....do.....	1887	.93	.....	.11	.28	.....	.16	.03	.....	.01	.....	.....	Turner's Cotton Planters' Manual, p. 207.	3
4	.....do.....	1887	4.72	1.25	.07	.44	.06	.21	.12	.03	.04	.08	Trace	Analysis by Shephard, Charleston, S. C.	4
	Sea Island.....	1887	1.31	.....	.16	.28	.19	.18	.06	.....	.05	.03	.06	Turner's Cotton Planters' Manual, p. 207.	5
6	.....do.....	1887	1.50	.....	.17	.36	.09	.26	.02	.....	.08	.11	.02	Analysis by Higgins and Beckwell, Baltimore, Md.	6
7	Short staple.....	1887	1.50	.....	.06	.44	.21	.11	.03	.....	.08	.11	.02	C. T. Jackson, U. S. Patent Office Rpt. 1857, p. 298. From Hancock Co., Miss.	7
8	Upland.....	1874	1.75	.54	.18	.37	.....	.48	.17	.....	.....	.....	.....	C. T. Jackson, U. S. Patent Office Rpt. 1857, p. 298. From Hamburg, S. C.	8
9	.....do.....	1889	6.72	1.50	.28	.07	.64	.03	.16	.11	.09	.....	.02	H. C. White, Proc. Georgia State Agl. Soc., 1874, p. 45.	9
10	.....do.....	1890	6.77	1.80	.20	.05	.85	.03	.15	.16	.09	.....	.03	J. B. McBryde, Tennessee Sta. Bul., vol. 4, No. 5. Machine-ginned cotton.	10
	Minimum.....		4.72	.93	.20	.05	.28	.07	.02	.01	.01	.02	.02	J. B. McBryde, Tennessee Sta. Bul., vol. 4, No. 5. Lint separated from seed by hand in laboratory.	
	Maximum.....		6.77	1.80	.54	.18	.85	.21	.48	.17	.03	.09	.14		
	Average.....		6.07	1.37	.34	.10	.46	.09	.08	.02	.06	.07	.05		
	SEED.														
1	Upland.....	1877	3.90	.....	1.43	1.15	.....	.37	.46	.....	.27	.....	.11	Southern Cultivator, 35 (1877), p. 149. Analysis by W. C. Stubbs.	1
2	.....do.....	1874	3.60	.....	1.08	1.27	.03	.16	.54	.04	.12	.02	.21	Southern Cultivator, 32 (1874), p. 339. Analysis by W. J. Land. U. S. Dept. Agr. Rpt. 1874, p. 220.	2
3	.....do.....	1887	3.86	.....	1.77	.75	.....	1.15	.....	.....	.04	.....	.....	J. A. Turner, Cotton Planters' Manual, 1887, p. 183.	3
4	.....do.....	1887	3.80	.....	1.34	1.06	.10	.41	.40	.13	.12	Trace	Trace	Ibid., p. 183.	4
5	.....do.....	1887	9.51	4.03	1.44	1.40	.04	.24	.55	.02	.16	.02	.....	J. A. Turner, Cotton Planters' Manual, 1887, p. 207. Analysis by Higgins and Beckwell, Baltimore, Md.	5

a Assumed.

b Chlorin and loss.

Fertilizing constituents of the cotton plant—Continued.

No.		Date of analysis.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.	Soda.	Lime.	Magnesia.	Ferric oxide.	Sulphuric acid.	Chlorine.	Insoluble matter.	References and remarks.	No.
SEED—continued.																
6	Upland	.....	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	Georgia Dept. Agr. Rpt. 1886, p. 333. Analysis by Vile.	6
7	Long staple	1857	.....	3.66	.....	1.14	1.34	.31	.17	.61	.....	.01	.04	.01	C. T. Jackson, U. S. Patent Office Rpt. 1857, pp. 296-304. From St. Simons Island, S. C.	7
8	do	1857	.....	4.12	.....	1.06	1.23	.48	.19	.79	.....	.09	.04	.02	C. T. Jackson, U. S. Patent Office Rpt. 1857, pp. 296-304. From Hancock Co., Miss.	8
9	Short staple	1857	.....	3.90	.....	1.07	1.31	.40	.11	.76	.....	.09	.05	.01	C. T. Jackson, U. S. Patent Office Rpt. 1857, pp. 296-304. From Hamburg, S. C.	9
10	do	1857	.....	2.80	.....	.76	.73	.50	.11	.50	.....	.02	.03	.03	C. T. Jackson, U. S. Patent Office Rpt. 1857, pp. 296-304. From Jackson, Miss.	10
11	do	1874	.....	3.41	1.96	1.22	1.02	.08	.34	.41	.06	.22	.03	.....	H. C. White, Proc. Georgia State Agl. Soc., 1874, p. 45.	11
12	Upland	1852	.....	3.80	.....	1.35	1.06	.10	.41	.40	.12	.12	.18	Trace	T. J. Summers, Proc. Philadelphia Acad. 1852, Dec. Johnson, How Crops Grow, p. 156.	12
13	do	1890	7.04	3.29	3.07	1.02	1.17	.02	.19	.50	.....	.13	.....	.02	J. B. McBryde, Tennessee Sta. Bul., vol. 4, No. 5.	13
14	do	1888	8.72	.....	2.98	1.30	1.24	.....	.....	.....	.....	.....	.....	.....	South Carolina Sta. Rpt. 1888, p. 155.	14
15	do	1888	.....	.....	2.45	1.37	1.23	.....	.....	.....	.....	.....	.....	.....	Texas Sta. Bul. 2.	15
	Minimum	.....	7.04	2.80	1.96	.76	.73	.02	.11	.40	.02	.01	.02	.01		
	Maximum	.....	9.51	4.96	3.17	1.77	1.63	.50	1.15	.79	.13	.27	.18	.21		
	Average	.....	8.42	3.78	3.13	1.27	1.17	.20	.25	.55	.07	.12	.05	.06		
HULLS.																
1	From upland seed	1873	.....	.....	.54	.95	.93	.....	.....	.....	.....	.08	.....	.05	Rural Carolinian. 4 (1873), p. 141.	1
2	do	1873	.....	2.11	.96	.33	.36	.01	1.09	.16	.02	.....	.....	.....	Southern Cultivator, 31 (1873), p. 334. Analysis by H. C. White.	2
3	do	1889	11.30	2.55	.74	.16	1.24	.02	.17	.28	.....	.09	.01	.....	J. B. McBryde, Tennessee Sta. Bul., vol. 4, No. 5.	3
4	do	1888	10.17	2.07	.70	.13	1.12	.....	.....	.23	.....	.....	.....	.....	do	4
5	do	1888	11.45	2.99	.76	.28	1.06	.20	.20	.29	.....	.....	.....	Trace	Massachusetts State Sta. Bul. 29.	5
6	do	1888	8.76	.....	.74	.18	1.07	.22	.22	.25	.....	.....	.....	.11	do	6
7	do	1893	.....	.....	.69	.56	1.08	.....	.....	.....	.....	.....	.....	.....	do	7
8	do	1882	9.16	2.28	.35	.09	1.32	.....	.17	.35	.04	.09	.05	.04	New Jersey Sta. Rpt. 1893, p. 102.	8
	Minimum	.....	8.76	2.07	.35	.09	.36	.01	.13	.16	.02	.08	.....	.01	North Carolina Sta. Rpt. 1882, p. 99. Hulls carefully separated from kernels by hand.	
	Maximum	.....	11.45	2.99	.86	.56	1.32	.02	1.09	.35	.04	.09	.....	.11		
	Average	.....	8.17	2.40	.69	.25	1.02	.02	.18	.26	.03	.08	.....	.05		

COTTON-HULL ASHES. <i>b</i>													
9	Minimum.....	25	2.37	7.02	1.30	.86	2.85	.92	2.41	.21	.96		
	Maximum.....	22.30	15.37	44.72	3.86	10.35	17.15	4.93	2.71	3	43.30		
	Average (185 analyses).....	9	9.08	23.40	2.58	8.85	9.97	2.07	2.56	1.60	14.04		
COTTON-SEED KERNELS.													
9	From upland seed.....	6.27	4.03	4.98	1.73	1.14	.16	.78	.03	.12	.01	North Carolina Sta. Rpt. 1882, p. 97.	
	MEAL.												
	From deoiled seed.....												
1	From deoiled seed.....			6.95	2.51	1.91						Connecticut State Sta. Bul. 73.	
2	do.....			7.29	1.84	2.17						Connecticut State Sta. Bul. 88.	
3	do.....			7.38	3.06	1.91						Connecticut State Sta. Bul. 91.	
4	do.....			7.13	3.40	1.91						do.....	
5	do.....			6.95	3.11	1.96						do.....	
6	do.....			7.65	2.81	1.81						do.....	
7	do.....			6.97	4.00	2.09						do.....	
8	do.....			7.42	3.69	2.08						Connecticut State Sta. Bul. 95.	
9	do.....			7.20								do.....	
10	do.....			6.94	2.71	1.85						Connecticut State Sta. Bul. 97. Damaged meal.	
11	do.....			6.75	2.56	1.83						do.....	
12	do.....			7.17	2.70	1.84						Connecticut State Sta. Bul. 97. Damaged meal; contains hulls.	
13	do.....			6.87	3.22	2.03						Connecticut State Sta. Bul. 99.	
14	do.....			6.65	3.48	1.94						do.....	
15	do.....			7.50	3.49	2.06						do.....	
16	do.....			6.44	3.34	1.96						Connecticut State Sta. Bul. 103.	
17	do.....			6.89	3.12	2.22						do.....	
18	do.....			6.74	3.22	2.16						do.....	
19	do.....			7.13	2.79	1.90						Connecticut State Sta. Bul. 113.	
20	do.....			7.15	2.80	1.79						do.....	
21	do.....			7.11	2.78	1.85						do.....	
22	do.....			6.97	2.21	1.83						do.....	
23	do.....			6.91	2.56	1.93						do.....	
24	do.....			6.60	3.39	2.13						do.....	
25	do.....			7.52	2.15	.99						do.....	
26	do.....			7.12	3.10	1.80						do.....	
27	do.....			6.99	2.32	1.37						Connecticut State Sta. Bul. 116.	
28	do.....			6.90	3.31	1.99						do.....	
29	do.....			7.01	3.28	1.97						do.....	
30	do.....			8.08	2.65	1.78						do.....	
31	do.....			6.74	3.04	1.94						do.....	
32	do.....			6.76	3.04	1.87						do.....	
33	do.....			6.61	3.23	1.89						do.....	
34	do.....			6.65	3.43	2.06						do.....	
35	do.....			6.10	3.15	1.95						do.....	
36	do.....			4.49	1.83	1.67						Connecticut State Sta. Bul. 116. Seed of Sea Island cotton ground with hulls.	

b Carbonic acid: Minimum, 9.56; maximum, 11.59; average (185 analyses), 10.57 per cent.

a Phosphoric acid excluded from average.

[illegible]

[illegible]

Proximate constituents of the cotton plant.

No.	Date of analysis.	Fresh or air-dry material.					References and remarks.	No.
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.		
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
ENTIRE PLANT.								
1	Collected Oct. 25.....	7.36	5.81	9.13	30.94	42.84	Tennessee Sta. Bul., vol. 4, No. 5.....	1
2	Collected June 3.....	10	15.62	21.49	16.38	32.51	Mississippi Sta. Tech. Bul. 1. Water assumed.....	2
3	Collected June 23.....	10	14.59	22.09	18.79	29.98	.....do.....	3
	Average.....	9.12	12.01	17.57	22.04	35.11		
PLANT AFTER SEED COTTON WAS REMOVED.								
4	Mature plants.....	6.51	5.30	6.06	35.33	44.18	North Carolina Sta. Rpt. 1882, p. 133.....	4
5	.....do.....	10.76	5.34	5.67	40.27	36.92	Tennessee Sta. Bul., vol. 4, No. 5. Stems and empty bolls of cotton plant—no leaves.....	5
6	.....do.....	12.77	7.75	7.31	27.55	42.35	North Carolina Sta. Bul. 906.....	6
	Average.....	10.01	6.13	6.35	34.38	41.15		
ROOTS.								
1	Mature plants.....	7.29	3.34	4.06	48.57	34.56	Tennessee Sta. Bul., vol. 4, No. 5.....	1
2	Collected July 2.....	10	6.52	7.01	42.35	31.95	Mississippi Sta. Tech. Bul. 1. Water assumed.....	2
3	Collected July 12.....	10	4.87	6.71	41.13	31.87	.....do.....	3
4	Collected July 22.....	10	4.18	5.67	43.94	33.62	.....do.....	4
5	Collected Aug. 1.....	10	6.54	7.20	42.28	31.79	.....do.....	5
6	Collected Aug. 11.....	10	4.04	5.87	48.40	30.26	.....do.....	6
7	Collected Aug. 22.....	10	3.01	5.75	43.73	34.88	.....do.....	7
8	Collected June 28.....	10	7.23	9.89	41.98	29.14	.....do.....	8
9	Collected Aug. 18.....	10	4.78	6.03	41.85	36.38	.....do.....	9
10	Collected July 8.....	10	4.18	5.35	38.55	39.15	.....do.....	10
11	Collected July 18.....	10	4.25	6.08	45.32	32.44	.....do.....	11
12	Collected July 28.....	10	3.29	3.65	45.51	35.41	.....do.....	12
13	Collected Aug. 7.....	10	3.48	4.45	47.27	33.31	.....do.....	13
14	Collected Aug. 17.....	10	3.21	3.29	44.71	37.04	.....do.....	14
15	Collected Aug. 28.....	10	3.54	2.92	47.29	34	.....do.....	15
	Minimum.....	3.01	3.01	2.92	38.55	29.14		
	Maximum.....	7.23	7.23	9.89	48.57	39.15		
	Average.....	9.82	4.43	5.60	44.19	33.92		

STEMS.									
1	At time of harvest.	1884	(66.76	3.62	1.56	19.95	7.03	1.18)	Dietrich and König, Futtermittel, vol. 2, p. 913. O. Kellner, Agt. Laborat. Z. Tokio. The stems contained albuminoid nitrogen, 0.44 per cent; albuminoids, 2.75 per cent.
2	Collected July 2.	1880	10	6.63	10.40	40.37	31.04	1.56	Mississippi Sta. Tech. Bul. 1. Water assumed.
3	Collected July 12	1880	10	5.30	10.40	42.81	30.27	1.13	do
4	Collected July 22	1880	10	4.10	9.94	41.65	30.77	1.54	do
5	Collected Aug. 1.	1880	(10	5.41	10.02	43.17	25.89	1.41)	Mississippi Sta. Tech. Bul. 1. Adds 100.90. Water assumed.
6	Collected Aug. 11.	1880	10	3.93	6.49	47.36	30.22	2	Mississippi Sta. Tech. Bul. 1. Water assumed.
7	Collected Aug. 22.	1880	10	2.75	6.04	49.44	29.75	2.02	do
8	Collected June 18.	1891	10	9.64	20.45	32.51	25.59	1.81	do
9	Collected June 28.	1891	10	6.44	11.02	37.56	33.27	1.71	do
10	Collected July 8.	1891	10	5.31	11.13	34.64	36.43	2.49	do
11	Collected July 18.	1891	10	5.22	9.60	33.32	39.87	1.99	do
12	Collected July 28.	1891	10	4.44	10.50	39.95	31.61	3.50	do
13	Collected Aug. 7.	1891	(10	4.27	10.16	36.61	33.15	2.21)	Mississippi Sta. Tech. Bul. 1. Adds 96.40. Water assumed.
14	Collected Aug. 17.	1891	10	4.07	6.87	42.54	34.88	1.64	Mississippi Sta. Tech. Bul. 1.
15	Collected Aug. 28.	1891	10	3.92	6.25	42.71	35.51	1.61	do
16		1889	10.06	4.09	4.90	45.16	35.04	.81	Tennessee Sta. Bul., vol. 4, No. 5.
	Minimum			2.75	4.90	32.51	25.59	.81	
	Maximum			9.64	20.45	49.44	39.87	3.50	
	Average		10	5.23	9.54	40.77	32.63	1.83	
LEAVES.									
1	Mature plants.	1889	10.82	14.24	15.06	10.04	43.32	5.52	Tennessee Sta. Bul., vol. 4, No. 5.
2	Collected July 2.	1890	10	13.68	23.76	13.69	34.51	4.36	Mississippi Sta. Tech. Bul. 1. Water assumed.
3	Collected July 12	1890	10	14.09	24.53	13.19	33.89	4.30	do
4	Collected July 22	1890	10	14.99	23.77	11.74	34.64	4.86	do
5	Collected Aug. 1.	1890	10	15.32	22.84	16.73	29.72	5.39	do
6	Collected Aug. 11.	1890	10	12.33	20.08	18.15	35.13	4.31	do
7	Collected Aug. 22.	1890	10	13.08	19.46	13.04	37.37	7.55	do
8	Collected June 18.	1891	10	11.92	26.64	11.15	36.82	3.97	do
9	Collected June 28.	1891	10	12.17	24.19	11.45	37.10	5.09	do
10	Collected July 8.	1891	10	11.39	23.29	11.39	37.04	6.89	do
11	Collected July 18.	1891	10	11.57	22.17	12.51	37.54	6.21	do
12	Collected July 28.	1891	10	13.73	22.06	11.29	35.14	7.78	do
13	Collected Aug. 7.	1891	10	11.86	20.94	12.79	37.03	6.48	do
14	Collected Aug. 17.	1891	10	11.93	18.98	11.93	38.52	8.64	do
15	Collected Aug. 28.	1891	10	10.73	16.74	9.50	44.16	8.87	do
	Minimum			10.73	15.06	9.50	29.72	3.97	
	Maximum			15.32	26.64	18.15	44.16	8.87	
	Average		10.05	12.87	21.64	12.57	36.82	6.05	

Proximate constituents of the cotton plant—Continued.

No.	Date of analysis	Fresh or air-dry material.						References and remarks.	No.
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.		
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
BOLLS, WITH CONTENTS									
1	Collected July 22, 1890	10	6.02	19.48	14.92	46.82	2.73	Mississippi Sta. Tech. Bul. 1. Water assumed.	1
2	Collected Aug. 1, 1890	10	3.71	18.66	23.73	38.78	3.85	do	2
3	Collected Aug. 11, 1890	10	5.25	15.83	29.73	35.65	3.54	do	3
4	Collected Aug. 22, 1890	10	5.11	18.98	30.36	26.85	8.70	do	4
5	Collected Aug. 7, 1891	10	3.87	11.73	7.04	64.60	2.76	do	5
6	Collected Aug. 17, 1891	10	3.43	10.65	13.27	59.78	2.87	do	6
	Minimum		3.43	10.65	7.04	26.85	2.73		
	Maximum		6.02	19.48	30.36	64.60	8.70		
	Average		4.90	15.89	19.72	45.42	4.07		
7	Burs.	11.92	7.34	6.96	32.50	39.90	1.38		7
8	Upland	6.74	1.65	1.50	83.71	5.79	.61	Tennessee Sta. Bul., vol. 4, No. 5.	8
SEED.									
1	Character not known	8.86	6.78	22.73	24.69	7.58	29.34	Dietrich and König, Futtermittel, vol. 1, p. 578.	1
2	1870	9.34	2.89	13.62	19.74	36.70	17.71	do	2
3	do	10.28					19.49	do	3
4	Thessalian seed	10.17	3.73	15.44	21.13	32.45	17.08	do	4
5	Amerieum seed	1881	4.30	16.88	27.60	28.12	14.86	do	5
6	Egyptian seed	1884	4.18	13.50	20.13	20.63	24.76	do	6
7	do	11.42	4.29	13.94	18.93	20.08	25.34	do	7
8	Character not known	8	8	29.70	32.40	11.80	10.40	do	8
	Minimum	8	2.89	13.62	18.93	7.58	10.40		
	Maximum	11.42	8	29.70	32.40	36.70	29.34		
	Average	9.76	4.86	19.56	23.46	22.45	19.91		
9	Whole cotton seed	(11.34)	6.54	23.72	21.24	30.98	6.18)	Boston Jour. Chem., vol. 5, 1871, p. 102. Rural Carolinian, vol. 2, p. 560. Voelcker given as authority. Fat very low.	9
10	South Carolina seed	9.50	5.70	20.10	17.60	27	20.10	Animal and Vegetable Fats and Oils, W. T. Braunt, 1888, p. 222. Analyses taken from American Analyst.	10
11	Georgia seed	10.10	5.90	20.30	19.20	28.30	16.20	do	11
12	do	9.80	6.10	20.40	19.80	26.80	17.10	do	12

13	do	Undecorticated American seed	8.20	6.40	21.80	22.40	21.60	19.60	do	Animal and Vegetable Fats and Oils, W. T. Brannin, 1888, p. 222. Analyses taken from American Analyst. Fat low	13
14	do	do	11.50	6.20	23.20	20.40	33.60	5.10	do	do	14
15	Upland seed	1891	(10.11	3.90	7.40	24.61	33.21	20.77)	Alabama Sta. Bul. 25. Protein low	15	
16	do	1890	(12.61	6.42	19.54	29.95	10.45	22.83)	Arkansas Sta. Rpt. 1890, p. 138. Adds 101.80	16	
17	do	1890	8.64	3.47	15.80	23.92	29.06	19.11	Georgia Sta. Bul. 7	17	
18	Crushed cotton seed	1889	(10	5.82	22.68	23.11	27.90	20.49)	Mississippi Sta. Bul. 8	18	
19	Cooked cotton seed	1889	(54.08	2.67	10.41	10.61	12.82	9.41)	Mississippi Sta. Bul. 8. Adds 110	19	
20	Upland seed	1892	17.51	2.90	14.49	20.30	25.45	19.38	North Carolina Sta. Bul. 87d. 1892	20	
21	Roasted cotton seed	1892	(9.32	2.27	16.10	24.04	25.79	22.48)	do	21	
22	Upland seed	1889	(8.12	4.53	20.75	20.86	20.87	20.28)	Tennessee Sta. Bul., vol. 2, No. 3	22	
23	do	1890	7.04	3.29	19.18	22.43	26.44	21.62	Tennessee Sta. Bul., vol. 4, No. 5	23	
24	do	1889	9.90	3.34	21.70	28.74	17.31	18.92	Texas Sta. Bul. 6	24	
25	Roasted cotton seed	1891	(2.92	8.72	17.75	16.81	21.10	32.70)	Texas Sta. Bul. 15	25	
Kühn's average:											
Minimum											
Maximum											
Average (all analyses)											
Wolff's average											
HULLS.											
1	Probably from upland seed	1888	10.17	2.47	4.40	46.17	34.67	2.12	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, Massachusetts State Sta. Rpt. 1888, p. 92.	1	
2	do	1888	11.45	3	4.76	35.75	41.24	3.80	do	2	
3	do	1889	10.05	2.58	3.46	44.35	38.12	1.44	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, Arkansas Sta. Bul. 9.	3	
4	do	1890	9.96	2.30	3.56	51.40	32.03	0.75	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, Georgia Sta. Bul. 7.	4	
Average											
5	Probably from upland seed	1883	13.30	2.70	3.89	44.60	35.51	2.02	Dietrich and König, Futtermittel, vol. 1, p. 264. M. Siewert, Landw. Vers. Stat., 30 (1884), p. 160.	5	
6	do	1891	12.76	2.94	2.78	44.84	34.51	2.17	Alabama College Sta. Bul. 25.	6	
7	do	1890	10.55	2.52	4.83	50.48	30.82	0.80	Arkansas Sta. Rpt. 1890, p. 138	7	
8	do	1892	9.28	2.86	4.37	42.01	39.28	2.20	Kentucky Sta. Rpt. 1892, p. 13	8	
9	do	1893	8.15	2.58	3.77	42.80	41.06	1.64	Massachusetts State Sta. Bul. 48	9	
10	do	1891	11.44	2.93	4.38	40.32	35.52	5.41	North Carolina Sta. Bul. 80c	10	
11	do	1892	16.73	1.77	3.68	37.85	37.12	2.85	North Carolina Sta. Bul. 87d	11	
12	do	1892	15.63	2.24	4.36	38.07	36.41	3.29	do	12	
13	do	1892	15.26	2.09	3.70	39.42	37.04	2.49	do	13	
14	do	1894	12.35	1.65	4.22	43.48	35.56	2.74	North Carolina Sta. Bul. 94	14	
15	do	1888	11.30	2.93	4.60	38.90	40.19	2.68	South Carolina Sta. Rpt. 1888, p. 148	15	
16	do	1889	7.25	2.88	3.75	42.83	41.75	1.54	Tennessee Sta. Bul., vol. 2, No. 3	16	
17	do	1889	13.01	4.43	4.68	47.88	28.86	1.14	Texas Sta. Bul. 6	17	

Proximate constituents of the cotton plant—Continued.

No.	Date of analysis.	Fresh or air-dry material.						References and remarks.	No.
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.		
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		
HULLS—continued.									
18	1890	9.96	3.35	5.06	66.95	12.41	2.27	Texas Sta. Bul. 13	18
19	1890	(10.03)	4.01	5.37	55.15	22.19	2.25	do	19
20	1890	9.98	2.92	5.37	52.71	26.74	2.28	do	20
21	1891	10	3.07	4.72	52.43	27.77	2.01	Texas Sta. Bul. 15. Water assumed.	21
22	1891	10	3.11	3.46	48.37	33.62	1.44	do	22
	Minimum	7.25	1.65	2.78	35.75	12.41	0.75		
	Maximum	16.73	4.43	5.37	66.95	41.24	5.41		
	Average (all analyses)	11.36	2.73	4.18	45.32	34.19	2.22		
COTTON-SEED BRAN AND COTTON-SEED FEED.									
1	1890	10.03	4.92	24.13	21.39	34.06	5.47	Connecticut State Sta. Rpt. 1890, p. 175	1
2	1892	8.86	2.87	17.81	24.52	42.99	2.95	Connecticut State Sta. Rpt. 1892, p. 150. Half hulls and half meal.	2
3	1894	10.50	3.22	10.63	27.95	45.25	2.85	Massachusetts State Sta. Bul. 56.	3
4	1888	11.99	2.18	6.37	30.83	47.33	1.33	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 146. Connecticut State Sta. Rpt. 1888, p. 145.	4
5	1894	13.07	2.45	7.80	43.28	30.67	2.73	Pennsylvania Sta. Bul. 28	5
6	1894	13.07	3.39	10.26	33.12	38.77	3.39	do	6
7	1894	13.07	2.55	8.43	32.54	40.66	2.75	do	7
8	1894	13.07	2.92	10.65	34.31	36.01	3.04	do	8
	Minimum	8.86	2.18	6.37	21.39	30.67	1.33		
	Maximum	13.07	4.92	24.13	43.28	47.33	5.47		
	Average	11.66	3.06	12.01	30.59	36.22	3.06		
KERNELS.									
1	1856	6.57	8.91	31.86	7.30	14.82	31.28	Dietrich and König, Futtermittel, vol. 1, p. 579. T. Anderson, Trans. Higl. Soc. 1860, July, p. 376.	1
2	1870	7.54	8.60	27.20	32	71	23.95	Dietrich and König, Futtermittel, vol. 1, p. 579. C. Schaedler, Technologie der Fette, Berlin, 1883, p. 406.	2
3	1870	8.12	9.44	28.12	33	74	20.58	do	3
4	1870	7.90	5	29.40	1.96	17.96	37.84	Dietrich and König, Futtermittel, vol. 1, p. 579. Sievert, Landw. Vers. Stat. 30 (1884), p. 145.	4
	Average	7.53	7.99	29.14	4.68	28.33	24.33		

5	Probably from upland seed	1870	6.14	7.02	33.57	7.16	9.11	37	Southern Planter and Farmer, 4 (1870), p. 204. From Cincinnati Gazette; analysis by E. S. Wayne.
6	do	1882	6.27	4.03	29.25	4.38	19.52	36.55	North Carolina Sta. Rpt., 1882, p. 97. Kernels care-fully separated from hulls by hand.
7	do	1889	6.04	5.41	33.06	3.09	15.81	36.59	Tennessee Sta. Bul., vol. 2, No. 3
	Minimum		6.04	4.03	27.20	1.90	9.11	20.58	
	Maximum		8.12	9.44	33.57	7.30	19.52	37.84	
	Average		6.94	6.92	30.35	4.76	21.39	29.64	
UNDECORTICATED COTTON-SEED CAKE.									
1	Source of seed not reported.	1850	11.19	5.64	24.69			9.08	Dietrich and König, Futtermittel, vol. 1, p. 716.
2	do	1855	6.58	8.09	28.31	10.64	26.98	19.40	do
3	do	1857	10.53	7.31	22.62	26.96	26.48	6.10	do
4	do	1857	12.03	6.29	25.62	19.79	29.90	6.37	do
5	do	1857	11.46	6.02	22.94	16.99	36.52	6.07	do
6	do	1857	11.90	6.58	21.92			5.08	do
7	do	1857	14.20	10.22	18.21			9.83	do
8	do	1859	9.84	7.53	27.20	10.86	36.74	7.83	do
9	do	1865	7.55	5.53	22.68	25.65	31.83	6.76	do
10	do	1870	10.83	6.89	23.93	24.62	28.05	6.22	do
11	do	1872	11.50	6	22.90	21	32.60	5.40	do
12	do	1873	11.45	5.36	19.75	24.72	33.32	5.40	do
13	do	1874	13.25	5.27	23.94	17.89	32.80	6.85	do
14	do	1874	11.90	6.30	24.50	10.60	30.85	6.35	do
15	do	1878			28			4.92	do
16	do	1875			22.93			6.15	do
17	do	1876	11.98	6.53	21.93	19.50	32.05	8.31	do
18	do	1877			23.75			7.73	do
19	do	1878	10.50	6.92	23.49	24.71	28.13	6.25	do
20	do	1878	12.76	5.63	24.06	19.10	33.43	5.02	do
21	do	1878	9.53	6.33	30.81	17.16	28.78	7.39	do
22	do	1877			22.38			5.26	Dietrich and König, Futtermittel, vol. 1, p. 716. Very rich in lint.
23	do	1877			16.25			4.92	do
24	do	1877	14.31	5.14	21.89	20.76	32.39	5.51	Dietrich and König, Futtermittel, vol. 1, p. 716.
25	do	1878			24.30			5.80	do
26	do	1881			25.19			6.09	do
27	do	1881	10.98	6	27.69			4.80	do
28	do	1881	11.26	5.28	27.69	24.93	27.76	6.30	do
29	do	1881	10.34	6.98	23.06	25.53	27.12	7.01	do
30	do	1881	10.69	6.59	23.06	25.73	24.94	6.26	do
31	do	1881	11.36	8.15	23.86	25.34	27.05	7.04	do
32	do	1878	13.50	5.37	32.70	25.34	27.05	7.26	do
33	do	1878	14.50	5.47	19.29	25.56	27.92	3.51	do
34	do	1878	10.60	5.04	18.49			3.95	do
35	do	1878	18.20	12.75	18.12	23.66	31.32	4.76	do
36	do	1878	12.60	12.50	22.75	20.98	26.41	7.72	do
37	do	1878	11.85	8.96	33.69	10.67	27.13	5.90	do
	do	1878	(11.20	6.57	13.80	5.33	57.20		

a Nitrogen-free extract corrected

Proximate constituents of the cotton plant—Continued.

No.	Date of analysis.	Fresh or air-dry material.					References and remarks.	No.
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.		
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
UNDECORTICATED COTTON-SEED CAKE—continued.								
38	Source of seed not reported.....	14.15	5.15	25.37	22.32	28.55	Dietrich and König, Futtermittel, vol. 1, p. 716.....	38
39	do.....	13.90	4.91	23.28	20.32	33.03	do.....	39
40	do.....	13.50	5.13	25.52	19.25	33.17	do.....	40
41	do.....	12.50	5.33	24.76	23.96	28.37	do.....	41
42	do.....	12	7.94	23.34	20.11	32.30	do.....	42
43	do.....	13.20	5.12	22.50	19.83	34.17	do.....	43
44	do.....	13.80	5.08	26.05	18.40	31.07	do.....	44
45	do.....	13.40	5.26	25.17	18.40	32.80	do.....	45
46	do.....	11.30	6.20	21.87	19.96	35.77	do.....	46
47	do.....	1883	11.50	23.97	19.96	36.66	do.....	47
48	do.....	1883	10.60	26.60	16.79	29.09	do.....	48
49	do.....	1883	11.79	30.49	15.62	29.61	do.....	49
50	do.....	1883	9.72	23.69	24.93	28.38	do.....	50
51	do.....	1884	13.12	23.38	24.00	27.92	do.....	51
52	do.....	1884	13.66	5.04	23.63	17.64	do.....	52
53	do.....	1884	9.80	6.96	28.56	24.77	do.....	53
54	do.....	1885	10.38	6.56	27.69	.....	do.....	54
	Minimum.....	7.55	5.03	13.70	5.29	24.20		
	Maximum.....	14.50	12.51	33.69	25.59	56.78		
	Average (46 analyses, from No. 9).....	11.86	6.38	24.25	20.95	30.74		
55	Source of seed not reported.....	12.60	5.64	20.62	20.36	35.42	Biedermann's Centralblatt, vol. 2 (1877), p. 157. G. Reimers, Landw. Vers. Stat. 19 (1876), p. 161. J. A. Voelcker, Jour. Roy. Agr. Soc. England, vol. 21, p. 366.	55
56	do.....	11.21	4.33	16.75	27.17	37.34	Connecticut State Sta. Rpt. 1890, p. 175.....	56
57	do.....	11.12	4.69	22.93	17.48	36.11	do.....	57
58	do.....	8.60	4.87	25.50	17.65	35.12	do.....	58
59	do.....	10.08	5	23.19	18.39	36.86	do.....	59
60	do.....	10.67	10.67	23.04	17.71	29.09	do.....	60
61	do.....	9.36	4.72	25.94	16.83	37.38	do.....	61
62	do.....	8.82	4.78	27.06	17.73	35.94	do.....	62
	Minimum.....	7.55	4.33	13.70	5.29	24.20		
	Maximum.....	14.50	12.51	33.69	27.17	56.78		
	Average (all analyses).....	11.64	6.26	24.08	20.68	31.43		
Kühn's average:								
	Minimum.....	6.60	.....	18.20	17	26.50		
	Maximum.....	14.20	.....	28.30	27	36.70		
	Average.....	10	6.80	23.50	21.10	32		

Proximate constituents of the cotton plant—Continued.

No.	Date of analysis.	Fresh or air-dry material.					References and remarks.	No.
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.		
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
DECORTICATED COTTON-SEED CAKE—continued.								
47	Source of seed not known	1881		45.50			Dierich and König, Futtermittel, vol. 1, p. 718	47
48	do	1881		49.68			do	48
49	do	1881		49.70			do	49
50	do	1881		42	2.14	24.49	do	50
51	do	1879	7.38	50.15		19.35	do	51
52	do	1879	7.30	49.03		20.93	do	52
53	do	1879	7.13	45.62			do	53
54	do	1879		45.62			do	54
55	do	1880		43.26			do	55
56	do	1880		44.75			do	56
57	do	1880		48.19			do	57
58	do	1880	7.11	42.80	4.18	17.03	do	58
59	do	1880		40.75			do	59
60	do	1880		40.15			do	60
61	do	1880		42.25			do	61
62	do	1880		43.06	9.60	16.32	do	62
63	do	1881	7.58	40.22		21.60	do	63
64	do	1881	7.51	43.90	3.83	20.87	do	64
65	do	1881	6.63	47.75			do	65
66	do	1882	7.51	43.90	3.81	20.89	do	66
67	do	1881		47.30			do	67
68	do	1881		48.20			do	68
69	do	1881		43.40			do	69
70	do	1882		41.17			do	70
71	do	1882		38.54			do	71
72	do	1882		39.86			do	72
73	do	1882		43.80			do	73
74	do	1882		39.42			do	74
75	do	1882		41			do	75
76	do	1881	7.10	42.02			do	76
77	do	1881		48.91			do	77
78	do	1882		42.44			do	78
79	do	1882		44.41			do	79
80	do	1882		45			do	80
81	do	1882		44.75			do	81
82	do	1882		43.44			do	82
83	do	1883		44.58			do	83
84	do	1883		45.88			do	84
85	do	1883		44			do	85
86	do	1883		41.90			do	86

87	do	1883			43.97			17.06	87
88	do	1883			43.25			15.05	88
89	do	1883			46.60			11.60	89
90	do	1883			47.44			12.67	90
91	do	1883			41.81			16.88	91
92	do	1883			46.94			14.11	92
93	do	1883			45.88			12.69	93
94	do	1883			46.81			13.29	94
95	do	1880	7.85	37.50				13.93	95
96	do	1880	6.65	36.25				18.53	96
97	do	1880	9.25	6.63	45.63			12.62	97
98	do	1881	7.85	7.05	35			18.37	98
99	do	1881	9.40	7.90	38.13			14.34	99
100	do	1881	8.35	6.85	38.44			14.86	100
101	do	1882	9.60	7.55	45.91			9.76	101
102	do	1882	6.95	6.95	42.81			17.81	102
103	do	1882	6.25	6.60	43.75			15.70	103
104	do	1882	9.60	6.10	43.44			12.91	104
105	do	1882			46			14.54	105
106	do	1879	8.30	6.80	44.70	7.20	20.90	12.10	106
107	do	1880		7.60	42.90		21.70	14.80	107
108	do	1880	8.90		43.80	2.30		15.70	108
109	do	1880	8.60		43.70			11.50	109
110	do	1880	9.70		45			14.50	110
111	do	1880	7.70	44.10				12.20	111
112	do	1880	8.20	41.70				15.20	112
113	do	1880	6.50	43.20				15.50	113
114	do	1880	8.60	45.50				14.30	114
115	do	1880	9.60	42.80				16.30	115
116	do	1880	9.30	43.30				11	116
117	do	1880	7.80	43.30				13.30	117
118	do	1880	8.70	43.40				15	118
119	do	1880	9.80	42.20				11.20	119
120	do	1881	6.90	42				15.30	120
121	do	1881	8.10	43.40				14.90	121
122	do	1881	10	43				15.50	122
123	do	1881	9.20	44.10				12.20	123
124	do	1881	8.70	43.60				13.10	124
125	do	1881	8.60	45.10				14	125
126	do	1881	8.20	46.60				13.80	126
127	do	1881		41				18.80	127
128	do	1881		41.70				15.60	128
129	do	1881		44				18.70	129
130	do	1881		42.50				13.60	130
131	do	1881	7.40	43.40				16.10	131
132	do	1881	9.10	50				12.30	132
133	do	1881	9	50.40				11.40	133
134	do	1881	7.20	49.50				13.50	134
135	do	1881	9.30	43.90				15.20	135
136	do	1881	15.60	44.10				6.90	136
137	do	1881	11.70	45.80				7.10	137
138	do	1881	6.80	50.60				12.90	138

Proximate constituents of the cotton plant—Continued.

No.	Date of analysis.	DECORTICATED COTTON-SEED CAKE— continued.	Fresh or air-dry material.						References and remarks.	No.
			Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.		
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		
139	1881	Source of seed not known	7.50	42.10	42.10	13.50	13.50	13.50	Dietrich and König, Futtermittel, vol. 1, p. 718	139
140	1881	do	7.40	47.40	47.40	14.30	14.30	14.30	do	140
141	1881	do	7.40	42.10	42.10	13.50	13.50	13.50	do	141
142	1881	do	7.40	46.70	46.70	15.00	15.00	15.00	do	142
143	1881	do	7.40	46.70	46.70	13.90	13.90	13.90	do	143
144	1881	do	7.40	46.70	46.70	13.50	13.50	13.50	do	144
145	1881	do	7.40	44.20	44.20	18.10	18.10	18.10	do	145
146	1881	do	7.40	48.90	48.90	14.40	14.40	14.40	do	146
147	1881	do	7.40	47.40	47.40	16.90	16.90	16.90	do	147
148	1881	do	7.40	40.90	40.90	16.20	16.20	16.20	do	148
149	1881	do	7.40	50.00	50.00	12.70	12.70	12.70	do	149
150	1881	do	7.40	47.00	47.00	14.40	14.40	14.40	do	150
151	1881	do	7.40	46.80	46.80	10.10	10.10	10.10	do	151
152	1881	do	7.40	47.10	47.10	14.00	14.00	14.00	do	152
153	1881	do	7.40	43.40	43.40	16.20	16.20	16.20	do	153
154	1881	do	7.40	45.10	45.10	13.20	13.20	13.20	do	154
155	1882	do	7.40	45.60	45.60	17.60	17.60	17.60	do	155
156	1882	do	7.40	44.10	44.10	13.90	13.90	13.90	do	156
157	1882	do	12.20	42.30	42.30	14.90	14.90	14.90	do	157
158	1882	do	7.40	43.80	43.80	15.20	15.20	15.20	do	158
159	1882	do	6.80	49.80	49.80	13.90	13.90	13.90	do	159
160	1882	do	9.00	45.00	45.00	14.50	14.50	14.50	do	160
161	1882	do	8.70	46.00	46.00	12.60	12.60	12.60	do	161
162	1882	do	9.50	46.40	46.40	12.00	12.00	12.00	do	162
163	1882	do	9.80	44.70	44.70	14.90	14.90	14.90	do	163
164	1882	do	8.00	47.60	47.60	18.30	18.30	18.30	do	164
165	1882	do	8.00	41.50	41.50	13.90	13.90	13.90	do	165
166	1882	do	9.70	44.60	44.60	14.30	14.30	14.30	do	166
167	1882	do	9.40	45.90	45.90	14.30	14.30	14.30	do	167
168	1882	do	8.10	42.00	42.00	14.30	14.30	14.30	do	168
169	1882	do	9.00	46.70	46.70	14.30	14.30	14.30	do	169
170	1882	do	7.60	44.10	44.10	15.30	15.30	15.30	do	170
171	1882	do	8.60	44.00	44.00	15.40	15.40	15.40	do	171
172	1882	do	8.30	45.20	45.20	13.60	13.60	13.60	do	172
173	1882	do	9.20	44.00	44.00	14.50	14.50	14.50	do	173
174	1882	do	8.40	46.30	46.30	14.30	14.30	14.30	do	174
175	1882	do	8.40	43.90	43.90	16.30	16.30	16.30	do	175
176	1882	do	8.30	43.70	43.70	14.90	14.90	14.90	do	176
177	1882	do	8.50	43.00	43.00	15.40	15.40	15.40	do	177
178	1882	do	8.50	46.10	46.10	13.40	13.40	13.40	do	178

179	.....do	1882	6.90	.....	46.40	.....	15.90	.....do	179
180	.....do	1882	7.90	.....	46.30	.....	16.40	.....do	180
181	.....do	1882	8.40	.....	47.30	.....	16.40	.....do	181
182	.....do	1882	8.80	.....	45	.....	14	.....do	182
183	.....do	1882	7.70	.....	48.70	.....	14	.....do	183
184	.....do	1882	7.80	.....	47.50	.....	14	.....do	184
185	.....do	1882	8.40	.....	46.80	.....	12.10	.....do	185
186	.....do	1882	9.60	.....	46.10	.....	11.70	.....do	186
187	.....do	1882	9.70	.....	44.70	.....	14.40	.....do	187
188	.....do	1882	8.20	.....	43.40	.....	13.60	.....do	188
189	.....do	1882	9.30	.....	45.40	.....	13.20	.....do	189
190	.....do	1882	8.80	.....	42	.....	15	.....do	190
191	.....do	1882	9.60	.....	41.50	.....	15.10	.....do	191
192	.....do	1882	8	.....	46.70	.....	16.40	.....do	192
193	.....do	1882	8.40	.....	45.10	.....	9.60	.....do	193
194	.....do	1882	8.60	.....	44.40	.....	14.30	.....do	194
195	.....do	1882	8.40	.....	43.60	.....	14.90	.....do	195
196	.....do	1882	7.30	.....	46.10	.....	17	.....do	196
197	.....do	1882	8.50	.....	45.30	.....	15.30	.....do	197
198	.....do	1882	8.40	.....	46.90	.....	15.60	.....do	198
199	.....do	1882	9.10	.....	42.40	.....	14.30	.....do	199
200	.....do	1882	8.50	.....	43.20	.....	15	.....do	200
201	.....do	1882	7.50	.....	47	.....	17.10	.....do	201
202	.....do	1882	9.10	.....	41.50	.....	16.40	.....do	202
203	.....do	1882	8.10	.....	44.90	.....	14.40	.....do	203
204	.....do	1882	8.70	.....	43.40	.....	14.20	.....do	204
205	.....do	1882	8	.....	45.90	.....	16.70	.....do	205
206	.....do	1882	7.20	.....	46.30	.....	14.70	.....do	206
207	.....do	1882	7.40	.....	46	.....	16.70	.....do	207
208	.....do	1882	6.60	.....	45.50	.....	18.30	.....do	208
209	.....do	1882	6.60	.....	43.70	.....	12.70	.....do	209
210	.....do	1882	8.40	.....	50.70	.....	11.20	.....do	210
211	.....do	1882	8.80	.....	48.40	.....	14.40	.....do	211
212	.....do	1882	8	.....	45.90	.....	15.10	.....do	212
213	.....do	1882	7	.....	41.80	.....	16.20	.....do	213
214	.....do	1882	7.60	.....	44.10	.....	15.20	.....do	214
215	.....do	1882	8.60	.....	44.90	.....	12.50	.....do	215
216	.....do	1882	8.30	.....	45.60	.....	14.60	.....do	216
217	.....do	1882	8.90	.....	44.20	.....	14.60	.....do	217
218	.....do	1882	9.70	.....	42.20	.....	15.50	.....do	218
219	.....do	1882	8.40	.....	45.70	.....	14.70	.....do	219
220	.....do	1882	10.40	.....	47	.....	11.80	.....do	220
221	.....do	1882	10.10	.....	43.90	.....	10.90	.....do	221
222	.....do	1882	9.70	.....	37	.....	10.90	.....do	222
223	.....do	1882	10.60	.....	45.10	.....	13.70	.....do	223
224	.....do	1882	10.90	.....	41.80	.....	13.60	.....do	224
225	.....do	1882	9.10	.....	40.30	.....	16.30	.....do	225
226	.....do	1882	10.20	.....	44.10	.....	13.70	.....do	226
227	.....do	1882	9	.....	47.50	.....	11.10	.....do	227
228	.....do	1882	9.30	.....	43.50	.....	12.60	.....do	228
229	.....do	1882	9.40	.....	44.50	.....	13.90	.....do	229
230	.....do	1882	10.10	.....	44	.....	14.10	.....do	230

Proximate constituents of the cotton plant—Continued.

No.		Date of analysis.	Fresh or air-dry material.					References and remarks.	No.
			Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
DECORTICATED COTTON-SEED CAKE—continued.									
231	Source of seed not known	1882	8.70	43.30	45.30	.....	.....	16.00	231
232	do	1882	8.30	43.10	45.40	.....	.....	19.70	232
233	do	1882	7.30	45.40	45.40	.....	.....	14.60	233
234	do	1882	7.90	46.10	46.10	.....	.....	13.80	234
235	do	1883	9.15	7.78	41.74	3.82	23.71	13.80	235
236	do	1886	7.18	4.22	38.50	6.23	22.49	21.38	236
237	do	1883	9.53	7.46	39.19	4.77	25.09	13.96	237
238	do	1884	9.81	7.56	43.44	6.20	18.64	18.64	238
239	do	1884	9.72	7.66	42.13	5.66	20.09	14.74	239
240	do	1884	9.68	8.22	43.86	6.40	18.96	12.88	240
241	Average of 37 analyses	1883	8.57	7	43.12	5.26	22.80	13.29	241
242	Average of 5 analyses	1884	7.82	7.39	41.38	5.10	23.13	15.56	242
243	Average of 2 analyses	1885	9.92	6.75	44.06	3.74	23.18	12.15	243
244	Average of 19 analyses	1886	8.77	6.63	43.96	4.32	23.80	12.52	244
245	Average of 5 analyses	1887	8.80	7.09	46.02	3.58	23.50	11.16	245
246	Average of 19 analyses	1881	.....	43.89	.....	.....	.....	14.58	246
247	Average of 45 analyses	1882	.....	44.14	.....	.....	.....	14	247
248	Average of 45 analyses	1883	42.85	42.85	42.85	.....	.....	15.53	248
249	Source of seed not known.	1881	42.80	42.80	42.80	.....	.....	15.50	249
250	Average of 11 analyses	1884	44.40	44.40	44.40	.....	.....	13.60	250
251	Average of 10 analyses	1885	43.80	43.80	43.80	.....	.....	13.55	251
252	Average of 1 analysis	1886	44.37	44.37	44.37	.....	.....	12.16	252
253	Average of 5 analyses	1888	47.50	47.50	47.50	.....	.....	11.60	253
	Minimum.....		6.25	4.15	34.71	2.14	13.15	7.14	
	Maximum.....		15.60	10.08	50.80	9.80	28.71	21.05	
	Average of all (429 analyses, from No. 13).		8.62	7.05	44.09	5.16	20.85	14.23	
	Average (23 analyses) 1870-1879.		8.76	7.29	44.24	6.27	19.62	13.82	
	Average (401 analyses) 1880 to date.		8.61	7	44.09	4.93	21.12	14.25	
	Wolf's average.....	1890	8.90	7.20	43.60	5.70	19.70	14.90	
	Kuhn's average: Minimum.....		7.70	.....	19.70	5.40	10.50	5.40	
	Maximum.....		14.30	.....	43.80	11.40	27.40	19.70	
	Average.....		10	7.90	40.90	9	15.80	16.40	

COTTON-SEED MEAL.

COTTON-SEED MEAL.									
1	Probably from undecorticated seed.	1857	9.40	7.75	43.81	10.44	11.21	17.39	Doerflich and König, Futtermittel, vol. 1, p. 721.
2	do	1857	10.21	7.61	40.25	5.84	16.38	19.71	do
3	Crushed seed, with hulls partially removed.	1866	8.86	6.78	40.25	24.69	7.58	29.34	do
4	Probably from decorticated seed.	1875	8.61	5.02	43.12	5.82	24.86	12.57	do
5	do	1877	7.24	5.83	41.45	3.08	24.39	18.01	do
6	Probably from undecorticated seed.	1878	8.27	7.77	46.37				do
7	Method of manufacture not known.	1880	9.74	7.58	40.75	3.72		16.04	do
8	do	1880			41.25			17.99	do
9	do	1880		3.58	43.12			15.24	do
10	do	1880			42.92			18	do
11	do	1880			43.62			12.13	do
12	do	1880		7.41	42.87			18.67	do
13	do	1880			40.62			18.92	do
14	do	1880			40.68			15.65	do
15	do	1881	7.34	7.70	41.66			17.29	do
16	do	1881		8.06	42.25			17.90	do
17	do	1881	6.93		42.43			20.20	do
18	do	1881			42.93			18.47	do
19	do	1881	6.80	6.80	41.75			20.61	do
20	do	1881	6.62	7.95	40.93			19.75	do
21	do	1881			42.15			15.92	do
22	do	1881			41.36			20.57	do
23	do	1881			41.48			20.66	do
24	do	1881			42.69			20.33	do
25	do	1881			41.40			19	do
26	do	1881			41.56			15.46	do
27	do	1881			39.78			16.98	do
28	do	1881			46.27			11.70	do
29	do	1881			45.88			10.85	do
30	do	1881	9.43		40.91	4.49		15.28	do
31	do	1881			43.25	6.87	20.14	15.90	do
32	do	1882		7.37	39.88			20.25	do
33	do	1882			42.13			13.87	do
34	do	1882			46.78			13.30	do
35	do	1882			40.69			15.62	do
36	do	1882			41			16.58	do
37	do	1882			43.38			13.16	do
38	do	1882			44.41			11.79	do
39	do	1882			45.03			12.17	do
40	do	1882			42.50			15.62	do
41	do	1882			46.88			14.68	do
42	do	1882			45.56			15.83	do
43	do	1882			43.66			15.49	do
44	do	1882			43.11			15.54	do

^aIn Dietrich and König's table 407 is given as the number of analyses recorded from 1870 to 1879 and 22 as the number recorded from 1880 to date, but evidently this is an error.

Proximate constituents of the cotton plant—Continued.

No.	Date of analysis.	Fresh or air-dry material.	References and remarks.						No.
			Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
COTTON-SEED MEAL—continued.									
45	1882	Method of manufacture not known...	Dietrich and König, Futtermittel, vol. 1, p. 721
46	1882	do	do
47	1882	do	do
48	1882	do	do
49	1882	do	do
50	1882	do	do
51	1882	do	do
52	1882	do	do
53	1882	do	do
54	1882	do	do
55	1882	do	do
56	1882	do	do
57	1882	do	do
58	1882	do	do
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80	1882	do	do
81	1882	do	do
82	1882	do	do
83	1882	do	do
84	1882	do	do

85	do	1883	40.06	14	do	85
86	do	1883	39.88	17.33	do	86
87	do	1883	41.13	18	do	87
88	do	1883	40.88	14.08	do	88
89	do	1883	40.88	14.68	do	89
90	do	1883	38.72	14.80	do	90
91	do	1883	38	16.80	do	91
92	do	1883	38.78	16.90	do	92
93	do	1883	43.50	13.21	do	93
94	do	1883	40.62	16.67	do	94
95	do	1883	43.12	3.58	21.51	do
96	do	1883	42.62	3.20	22.13	do
97	do	1883	42.80	4.18	17.20	do
98	do	1883	43.73	2	23.89	do
99	do	1883	45	4.65	16.35	do
100	Probably from decorticated seed.	1880	8.87	4.83	22.89	do
101	do	1881	7.34	4.53	23.73	do
102	do	1881	7.50	4.24	12.17	do
103	Method of manufacture not known.	1881	44.50	16	14.58	do
104	do	1881	39.40	14.50	do	do
105	do	1881	42.40	19.40	do	do
106	do	1881	41.50	17.18	do	do
107	do	1881	46.20	7.78	16.67	do
108	do	1881	44.44	13.30	12.80	do
109	do	1881	44.44	8.40	do	do
110	do	1881	44.44	10.00	do	do
111	do	1881	43.18	10.84	do	do
112	do	1881	44.72	18.80	do	do
113	do	1881	43.70	13.94	do	do
114	do	1881	46.67	12.80	do	do
115	do	1881	42.01	8.77	do	do
116	do	1881	41.95	15.46	do	do
117	do	1881	44.98	13.86	do	do
118	do	1881	45.56	10.04	do	do
119	do	1881	43.50	11.90	do	do
120	do	1881	47.30	15.94	do	do
121	do	1881	46.22	11.68	do	do
122	do	1881	45.42	13.40	do	do
123	do	1881	7.12	5	17.02	do
124	Probably from decorticated seed.	1881	6.90	10.52	do	do
125	do	1881	7.02	14	do	do
126	do	1886	6.55	5.00	21.50	do
127	Method of manufacture not known.	1884	5.87	5.74	21.66	do
128	do	1884	5.76	4.78	15.98	do
129	do	1884	5.74	4.13	15.78	do
130	Average of 10 analyses.	1883	6.96	16.45	16.80	do
131	Method of manufacture not known.	1884	42.80	5.48	15.80	do
132	Average of 32 analyses.	1884	42.40	21.53	15.20	do
133	Average of 39 analyses.	1885	43.30	14.60	do	do
134	Average of 20 analyses.	1885	44.80	14.30	do	do
135	Method of manufacture not known.	1885	45.69	13.35	do	do
136	do	1885	7.23	11.36	do	do
				2.52	22.90	11.42

158	.....do	1883	7.61	6.53	46.12	4.90	21.67	13.17	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Connecticut State Sta. Rpt. 1883, p. 89.	158
159	.....do	1883	7.29	6.85	45.31	5.32	21.93	13.30	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. New Jersey Sta. Rpt. 1883, p. 74.	159
160	.....do	1883	6.65	7.71	43.69	4.30	27.41	10.24	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. New Jersey Sta. Rpt. 1883, p. 74.	160
161	.....do	1883	6.89	7.80	42.56	8.05	21.58	13.12	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Massachusetts State Sta. Rpt. 1883, p. 84.	161
162	.....do	1883	9.13	6.91	42.75	5.71	23.84	11.66	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Massachusetts State Sta. Rpt. 1883, p. 84.	162
163	.....do	1883	8.38	7.79	38.91	6.17	26.89	11.86	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Wisconsin Sta. Bul. 3.	163
164	"New (roller) process"	1883	7.10	8.63	39.56	7	24.89	12.77	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Wisconsin Sta. Bul. 3.	164
165	"Old (press) process"	1883	8.15	6.84	33.54	6.80	31.08	13.59	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Wisconsin Sta. Bul. 3.	165
166	Probably from deoiled seed	1883	7.09	8.50	23.27	9.78	38.68	12.68	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Wisconsin Sta. Bul. 3.	166
167	.....do	1883	7.59	6.48	44	2.77	25.72	13.44	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Wisconsin Sta. Bul. 3.	167
168	.....do	1884	18.52	6.55	35.21	5.96	21.44	12.32	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. New York State Sta. Rpt. 1884, p. 332.	168
169	.....do	1885	10.67	6.63	43.25	29.06		10.39	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. New York State Sta. Rpt. 1885, p. 172.	169
170	.....do	1885	7.99	6.43	44.31	28.39		12.88	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Maine Sta. Rpt. 1885, p. 51.	170
171	.....do	1885	8.50	7	43.75	4.75	21.40	14.60	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Maine Sta. Rpt. 1885, p. 51.	171
172	.....do	1886	8.45	8.41	41.88	3.45	20.94	16.87	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. New York State Sta. Rpt. 1886, p. 366.	172
173	.....do	1886	7.95	6.96	44	4.10	21.93	15.06	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Connecticut State Sta. Rpt. 1886, p. 113.	173
174	.....do	1886	8.90	7.27	43.94	9.61	19.40	10.88	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Maine Sta. Rpt. 1886, p. 68.	174
175	.....do	1886	7.87	6.94	46.12	6.79	21	11.28	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Vermont Sta. Rpt. 1887, p. 133.	175
176	.....do	1887	6.64	7.90	40.42	5.85	24.22	14.97	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Vermont Sta. Rpt. 1887, p. 133.	176
177	.....do	1887	6.46	6.88	39.37	5.38	28.68	13.23	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Vermont Sta. Rpt. 1887, p. 133.	177
178	.....do	1888	9.55	7.20	44.22	6.50	23.77	8.76	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Vermont Sta. Rpt. 1887, p. 133.	178
179	.....do	1888	6.84	6.58	37.39	10.09	26.99	12.23	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Arkansas Sta. Rpt. 1888, p. 133.	179
180	.....do	1888	6.68	6.65	43.56	8.14	17.17	17.20	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Mass. State Sta. Rpt. 1888, p. 93.	180
181	.....do	1888	6.43	7.23	44.61	1.28	28.93	11.52	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. Vermont Sta. Rpt. 1888, p. 76.	181
182	.....do	1888	8.86	5.81	46.32	6.38	23.68	8.95	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. New York State Sta. Rpt. 1888, p. 238.	182
	Minimum.	.....	5.78	5.73	23.27	1.28	15.68	8.76	Jenkins and Winton, Comp. Analyses American Feeding Stuffs, p. 145. New Hampshire Sta. Bul. 8.	
	Maximum	.....	18.52	8.80	50.81	10.00	38.68	18.01		
	Average (37 analyses)	.....	8.17	7.17	42.31	5.62	23.65	13.08		

221	do	1893	6.52	7.09	44	3.60	28.79	10	do	221
222	do	1893	8.70	7.98	42.86	2.35	27.65	13.86	do	222
223	do	1889	8.70	6.70	46.80	6	23.80	8	Delaware Sta. Bul. 7.	223
224	do	1889	8.30	6.70	44.80	6.70	22.50	11	do	224
225	do	1889	8.90	6.60	47.70	6	23.20	7.60	do	225
226	do	1889	9	6.70	46.70	6	23.40	8.20	do	226
227	do	1889	6.40	6.54	47.18	2.83	25.73	11.32	Georgia Sta. Bul. 4. Nitrogen-free extract corrected.	227
228	do	1890	7.36	6.90	44.79	4.26	24.34	12.35	Georgia Sta. Bul. 7.	228
229	do	1890	7.10	7.27	49.23	3.13	23.26	10.01	Kansas Sta. Rpt. 1889.	229
230	do	1889	7.75	6.37	42.50	5.42	26.13	11.23	Kentucky Sta. Rpt. 1889, p. 19.	230
231	do	1889	7.11	6.89	44.38	6.40	21.53	13.69	Maine Sta. Rpt. 1889, Pt. II, p. 59.	231
232	do	1889	7.52	6.23	44.75	3.44	18.74	18.90	do	232
233	do	1889	7.54	5.38	44.18	5.75	21.52	10.65	do	233
234	do	1889	7.93	6.95	44.62	5.56	23.43	10.11	Maine Sta. Rpt. 1891, Pt. II, p. 61.	234
235	do	1891	9.30	6.35	43.58	8.11	23.08	11.88	Maryland Sta. Rpt. 1891, pp. 314, 318.	235
236	do	1891	6.75	6.40	43.41	5.88	22.15	13.41	do	236
237	do	1891	9.77	7.38	40.07	6.98	25.58	10.22	Massachusetts Sta. Bul. 41.	237
238	do	1893	10.13	7.39	41.33	6.52	24.17	10.46	do	238
239	do	1893	6.81	6.62	41.31	6.09	27.34	11.83	Massachusetts Sta. Bul. 49.	239
240	do	1894	5.58	7.21	42.57	4.80	26.24	13.60	do	240
241	do	1894	7.29	7.07	45.24	5.47	27.13	7.80	Massachusetts Sta. Bul. 52.	241
242	do	1894	8.99	6.46	45.82	5.03	24.91	8.79	Massachusetts Sta. Bul. 55.	242
243	do	1890	10.50	7.58	41.99	9.31	22.05	10.16	Massachusetts Sta. Rpt. 1890, p. 123.	243
244	do	1891	9.07	6.82	42.17	6.19	25.59	9.74	Massachusetts Sta. Rpt. 1891, p. 103.	244
245	do	1891	8.00	7.38	37.52	7.90	28.45	11.49	do	245
246	do	1892	9.06	7.50	47.18	6.51	18.42	11.49	do	246
247	do	1892	7.05	5.02	36.05	5.72	33.31	12.85	Massachusetts Sta. Rpt. 1892, p. 85.	247
248	do	1892	8.62	5.88	40.62	5.66	29.45	9.77	do	248
249	do	1892	8.53	6.90	44.12	5.37	24.41	10.07	do	249
250	do	1892	8.83	4.30	38.68	8.91	30.64	8.64	do	250
251	do	1892	6.17	5.01	26.18	7.21	26.18	13.31	do	251
252	do	1892	5.69	7.13	41.20	7.32	26.89	14.77	do	252
253	do	1893	7	6.93	41.22	6.17	27.33	11.35	Massachusetts Sta. Rpt. 1893.	253
254	do	1893	8.71	6.96	39.77	7.56	28.33	8.67	do	254
255	do	1893	6.20	6.91	41.94	5.45	27.27	12.23	Massachusetts Sta. Rpt. 1893. Nitrogen-free extract corrected.	255
256	do	1893	6.48	6.70	43.09	5.23	28.17	10.33	Massachusetts Sta. Rpt. 1893.	256
257	do	1894	8.14	7.95	44.38	5.61	22.72	11.20	Minnesota Sta. Bul. 36. Nitrogen-free extract corrected.	257
258	do	1889	8.40	7.80	40.68	8.07	26.41	8.64	Mississippi Sta. Bul. 8.	258
259	do	1892	8.50	6.99	42.10	7.27	26.61	8.14	Missouri Sta. Bul. 8.	259

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CLIMATOLOGY AND SOILS.

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INTRODUCTION.

Cotton production in the United States is limited by climatic conditions to that portion of the country south of latitude 37° . A few small areas are cultivated north of this on account of local peculiarities of the climate or market conditions, but for the most part the cultivation does not extend north of the northern boundary of North Carolina. Just after the war, when cotton was bringing a high price, the cultivation was extended into many northern localities, where the plant matures only in favorable seasons, but the cultivation of cotton in these northern areas has now been generally abandoned for more certain and, on the whole, more profitable crops for those localities.

Prior to 1860 cotton was cultivated on nearly every plantation in the South, but it was principally grown upon the deep, fertile loam soils, found by experience to be best adapted to it. At present, however, cotton is produced upon nearly all varieties of soils within the region in which the climatic conditions are favorable to its growth, and artificial fertilizers are depended upon to increase the yield or hasten the ripening of the crop on soils which are not naturally adapted to it.

With the present agricultural depression, affecting the cotton planter as it does the producer of all other staple agricultural crops, there must be a contraction of the acreage if for no other reason than to give up the cultivation of the crop on soils not adapted to it and turn them to their legitimate use in the production of other crops better adapted to them.

CLIMATE.

In treating of the climatic conditions favorable to the production of cotton it is apparent by glancing at a map showing the cotton acreage that a line crosses the country a little below latitude 37° , south of which the climatic conditions are generally favorable to the production of cotton, and north of which they are unfavorable on account of the short season and the relatively low mean temperature.

Broadly speaking,¹ the mean temperature of the year is about 15° higher in South Carolina, Georgia, Alabama, and Mississippi than in Massachusetts, New York, and Pennsylvania. During the winter the

¹ South Carolina Sta. Bul. No. 7, n. ser.

mean temperature is about 20° warmer at the South, and during the summer months about 10° . This of course means a longer and a warmer season. The daily range in temperature is nearly the same in both sections, but is slightly less in the South during the summer, giving more uniform conditions of growth, and is somewhat greater at the South during October and November, the ripening period of the cotton crop, which is an important factor in cotton production. The daily range in temperature increases, however, in both sections as the distance from the coast increases.

The mean annual rainfall for the northern section of the United States is about 40 inches, while at the South that amount is exceeded by some 16 or 17 inches. The rainfall in both sections generally increases from the winter, reaching a maximum about the middle of summer, the autumn being the driest period. This larger rainfall and higher temperature at the South give considerably more moisture in the air. The temperature of the dew-point at the South is 10° or 12° higher than in the Northern States, and a given volume of air contains nearly twice as much moisture. But as the amount of moisture which the air is capable of holding increases with the temperature, the per cent of the saturating quantity or the relative humidity is about the same at the South as in the Northern States mentioned. The relative humidity varies somewhat throughout the year, but it is slightly greater during the summer at the South than at the North.

The following are the essential features of a climate adapted to the cultivation of cotton: The season must be sufficiently long for the crop to mature. One of the most important factors, therefore, is the probable date of the last killing frost in the spring and of the earliest frost in the autumn, for cotton has a very long growing period. Cotton picking is often extended far into the winter, but the first killing frost of autumn checks the active growth of the plant, and the blossoms or young bolls starting at this time will not develop into mature fruit. The crop requires six or seven months of favorable growing weather for its development.

The next most important consideration is the amount and distribution of the heat and rainfall. Cotton is a plant which thrives in a very warm or even hot atmosphere, provided the atmosphere is moist and the transpiration is not so excessive as to overtax the powers of the plant. The temperature should be high and the daily range uniform during the early growing period of the plant. The mean daily temperature normally increases from the time the seed is put in until about the first of August, after which it as rapidly falls, making two distinct periods in the life of the plant. During the first period of high and increasing temperature the plant should be in full vegetative growth. Any great and sudden range in temperature, or any prolonged cold spell, is liable to check the vegetative growth of the plant and tend to ripen it, which is very undesirable during this stage of development. By the first or

middle of August the plant should have attained its full vegetative growth—that is, it should have stored up all of the food material it needs. From this time on a decreasing temperature and a greater range of temperature between day and night are favorable to the production of a maximum crop, for this checks the vegetative growth and induces the plant to convert the food material it has accumulated into fruit. The soil also should be drier during this second period.

As a rule the rainfall normally increases in the South from the spring to the middle of summer, when it decreases, and the climate during the autumn is usually remarkably dry and bracing. These conditions are favorable to cotton production. During the earlier period the rain should fall in frequent showers rather than in heavy storms, and the very best seasons are when these showers occur at night, giving with a large and well-distributed rainfall a large amount of sunshine.

These are the principal climatic conditions favorable to cotton production. They are gathered more from the experience of farmers than from the meteorologist, for the reason that the relations of climate to crop production are so involved and complex that it is impossible at present to give any adequate interpretation to the meteorological data and to show their full bearing upon crop production.¹

We are not at present able to interpret the temperature records and determine the exact character of a season from them, for while the monthly temperature may on the whole appear to have been extremely favorable, yet the temperature on one single day during the month or during one hour might have been so unfavorable as to have affected the crop to such an extent as to have a marked effect upon the subsequent yield, no matter how favorable subsequent conditions may have been. Continuous records by self-recording instruments will give much fuller information in regard to climatic conditions, but it will be long before we are able to give a satisfactory interpretation to these records as they affect the health, vigor, and production of a given crop.

We must not only consider the mean temperature or rainfall for the season or for the month, but the mean temperature and rainfall of each day and of each hour, for these may have a controlling influence upon crop production. This, of course, makes the relations exceedingly complex.

The following summary of tables, prepared by Prof. P. H. Mell and published in Bulletin 8 of the Weather Bureau of this Department, gives the principal features of the climatic conditions of different sections of the cotton belt during the growing season of the crop.

Table 1 gives the earliest and latest dates of the last killing frosts in the spring from 1871 to 1891, both inclusive, and gives the average date

¹When the conditions are such that there is a tendency to excessive growth of "weed" a dry hot May and June to check overgrowth of the plant may be found beneficial.

at which they have occurred. The heavy frosts at the South have generally ended by the 15th of April, and it is customary to plant cotton from April 1 to May 10, as there is then little chance of the crop being injured by the time it has germinated and appeared above the surface. It is not considered advisable, however, to begin planting before April 15 on account of the cool nights during this month, which are liable to reduce the vitality of the plants.

TABLE 1.—*Dates of last killing frosts in the cotton belt, exhibiting early and backward springs, from 1871 to 1891, inclusive.*

Station.	Earliest.	Latest.	Average.
ALONG THE NORTHERN LIMIT.			
Atlanta, Ga.....	Feb. 2, 1882	Apr. 8, 1886	Mar. 17
Charlotte, N. C.....	Mar. 10, 1884	May 3, 1879	Mar. 30
Chattanooga, Tenn.....	Jan. 25, 1880	Apr. 8, 1886	Mar. 18
El Paso, Tex.....	Mar. 7, 1885	Apr. 22, 1882	Mar. 31
Fort Davis, Tex.....	Feb. 25, 1888	Apr. 22, 1884	Apr. 1
Fort Elliott, Tex.....	Mar. 2, 1890	Apr. 30, 1880	Apr. 6
Fort Smith, Ark.....	Mar. 9, 1884	Apr. 5, 1887	Mar. 22
Knoxville, Tenn.....	Mar. 17, 1890	Apr. 25, 1883	Apr. 7
Little Rock, Ark.....	Feb. 22, 1882	Apr. 14, 1881	Mar. 21
Memphis, Tenn.....	Feb. 25, 1889	Apr. 16, 1882	Mar. 31
Nashville, Tenn.....	Feb. 2, 1882	May 1, 1886	Mar. 28
THROUGH THE MIDDLE PORTION.			
Auburn, Ala.....	Mar. 11, 1889	Apr. 6, 1886	Mar. 23
Augusta, Ga.....	Feb. 6, 1882	Apr. 14, 1885	Mar. 18
Charleston, S. C.....	Jan. 4, 1882	Apr. 2, 1881	Feb. 25
Hatteras, N. C.....	Jan. 4, 1882	Apr. 5, 1881	Feb. 23
Kitty Hawk, N. C.....	Jan. 18, 1878	Apr. 19, 1875	Mar. 12
Montgomery, Ala.....	Feb. 2, 1882	Apr. 6, 1886	Mar. 8
Palestine, Tex.....	Feb. 24, 1889	Apr. 7, 1886	Mar. 17
Shreveport, La.....	Jan. 12, 1887	Apr. 7, 1886	Feb. 24
Vicksburg, Miss.....	Jan. 16, 1874	Apr. 6, 1886	Feb. 27
Wilmington, N. C.....	Jan. 23, 1882	Apr. 20, 1890	Mar. 14
ALONG THE SOUTHERN LIMIT.			
Brownsville, Tex.....	Dec. 26, 1880	Mar. 1, 1890	Jan. 29
Cedar Keys, Fla.....	Dec. 7, 1887	Mar. 12, 1888	Jan. 22
Galveston, Tex.....	Dec. 26, 1880	Mar. 1, 1890	Jan. 27
Indianola, Tex.....	Nov. 30, 1878	Apr. 14, 1881	Feb. 7
Jacksonville, Fla.....	Dec. 18, 1880	Mar. 23, 1883	Feb. 3
Mobile, Ala.....	Dec. 27, 1880	Apr. 6, 1886	Feb. 21
New Orleans, La.....	Nov. 26, 1882	Mar. 14, 1886	Jan. 13
Pensacola, Fla.....	Dec. 27, 1880	Mar. 23, 1881	Feb. 24
Rio Grande City, Tex.....	Dec. 16, 1882	Mar. 2, 1890	Jan. 24
San Antonio, Tex.....	Dec. 7, 1878	Apr. 14, 1881	Feb. 11
Savannah, Ga.....	Jan. 4, 1884	Apr. 13, 1885	Feb. 26

¹ Also in 1887.

² Also in 1885.

Table 2 gives the date of the first killing frost of the autumn in the cotton belt from 1832 to 1890, inclusive. The detailed information for the separate localities is not published in the bulletin from which the table is taken. It is stated in a general way that at Charlotte, Chattanooga, and Nashville frosts may be expected as early as October 15; at Atlanta, Starksville, Vicksburg, and Palestine killing frosts usually occur as early as November 1, while along the coast of Georgia and Alabama they may be expected any time after November 15.

TABLE 2.—*Dates of the first killing frosts in the cotton belt.*

Year.	Oct.	Nov.	Dec.	Year.	Oct.	Nov.	Dec.
1832	20			1864			
1833	21			1865	20		
1834	20			1866			
1835		12		1867		26	
1836				1868		24	
1837	26			1869		21	
1838				1870		18	
1839				1871		29	
1840		14		1872		15	
1841	25			1873		7	
1842	25			1874			7
1843				1875			1
1844		14		1876		26	
1845	12			1877		19	
1846	19	30		1878		20	
1847		1		1879		21	
1848		26		1880		13	
1849		17		1881		23	
1850		6		1882		20	
1851		27		1883			12
1852				1884		24	
1853		14		1885		1	
1854				1886		13	
1855	25			1887		16	
1856	8			1888		18	
1857				1889		20	
1858	7			1890		17	
1859				1891		7	
1860	13			1892	25		
1861			24	1893	15		
1862				1894	9		
1863	24						

These tables show the length of the season in the different sections of the cotton belt.

The winters in the cotton belt are seldom severe and the temperature rarely reaches zero except in the northern portion, where the climatic conditions are liable to extreme or sudden changes. The conditions are generally unfavorable to cotton production where the winter and spring temperatures are very low, as the growing season is liable to be too short for the maturity of the crop.

Table 3 shows the minimum temperature of the three winter months in a number of localities in different sections of the cotton belt.

TABLE 3.—*Winter minimum temperature at stations of the cotton belt of the Southern States.*

Station.	Length of record.	Mini- mum.	Month and year.	Mean minimum.			Number of times minimum was zero and below.
				Dec.	Jan.	Feb.	
NORTHERN PORTION.							
	<i>Years.</i>	<i>°F.</i>		<i>°F.</i>	<i>°F.</i>	<i>°F.</i>	
Atlanta, Ga	13	2	Jan., 1886	37.6	35.4	39.7	2
Charlotte, N. C	13	5	Dec., 1880	35.5	33.8	37.4	2
Chattanooga, Tenn	13	7	Jan., 1886	35.6	34	37.7	2
El Paso, Tex	14	5	Dec., 1880	32.9	30.7	35.8	2
Fort Davis, Tex	11	3	Jan., 1886	33.2	30.1	34.8	2
Fort Elliott, Tex	10	14	Jan., 1888	25.6	18.7	24.2	12
Fort Smith, Ark.	10	7	Jan., 1886	33.8	26.8	32.3	3
Knoxville, Tenn.	21	16	Jan., 1884	32.3	30.6	34.2	7
Little Rock, Ark	13	5	Jan., 1886	38.5	33.7	38	1
Memphis, Tenn.	20	8	Jan., 1886	38.1	32.8	37.7	2
Nashville, Tenn.	21	10	Jan., 1884	33.9	30.5	34.1	9

TABLE 3.—*Winter minimum temperature at stations of the cotton belt, etc.*—Continued.

Station.	Length of record.	Mini- mum.	Month and year.	Mean minimum.			Number of times minimum was zero and below.
				Dec.	Jan.	Feb.	
MIDDLE PORTION.							
	<i>Years.</i>	<i>° F.</i>		<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	
Auburn, Ala.	14	3	Jan., 1884	39.7	38.2	44.8	0
Augusta, Ga.	20	6	Jan., 1886	39	38.8	42	0
Charleston, S. C.	20	10	Jan., 1886	44.8	44.5	46.2	0
Green Springs, Ala.	27	2	Jan., 1886				0
Hatteras, N. C.	17	8	Dec., 1880	42	39.3	41.9	0
Kitty Hawk, N. C.	17	5	Feb., 1886	40.1	36.6	39.4	0
Montgomery, Ala.	19	5	Jan., 1886	40.6	40.1	44.4	0
Palestine, Tex.	10	0	Jan., 1886	42.6	38.3	43.8	1
Shreveport, La.	20	1	Jan., 1886	41.6	58.2	43.1	0
Union Springs, Ala.	24	8	Jan., 1886				0
Vicksburg, Miss.	20	3	Jan., 1886	42.7	39.9	44.2	0
Wilmington, N. C.	21	9	Jan., 1884	39.9	38.9	41.5	0
SOUTHERN PORTION.							
Brownsville, Tex.	16	18	{Dec., 1880/ Jan., 1881}	53.5	50	55.2	0
Cedar Keys, Fla.	10	15.5	Jan., 1886	51.4	51	54.9	0
Galveston, Tex.	21	11	Jan., 1886	51.5	47.4	52.9	0
Indianola, Tex.	14	12	Jan., 1886	50.1	43.8	49.9	0
Jacksonville, Fla.	20	15	Jan., 1886	49.1	47.5	50.8	0
Mobile, Ala.	21	11	Jan., 1886	44.4	43.6	47.6	0
New Orleans, La.	21	15	Jan., 1886	48.7	47.3	51.2	0
Pensacola, Fla.	12	15	Jan., 1886	47.3	46.3	51	0
Rio Grande City, Tex.	15	19	Jan., 1881	50.5	47.7	54.2	0
San Antonio, Tex.	15	6	Jan., 1886	45.2	41	46.8	0
Savannah, Ga.	21	12	Jan., 1886	44.4	43.7	46.9	0

Table 4 gives the mean monthly temperature of stations in the different sections of the cotton belt during the growing season, Table 5 gives the mean minimum temperature, and Table 6 gives the mean maximum temperature of the same place.

TABLE 4.—*Mean monthly temperature of stations in the cotton belt.*

Station.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
NORTHERN SECTION.								
	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>	<i>° F.</i>
Atlanta, Ga.	61.6	68.9	75.7	78.3	76.3	71.1	62	50.7
Charlotte, N. C.	59.9	68.8	75.9	78.6	76.4	71.3	64.6	50.5
Chattanooga, Tenn.	62.7	68.9	75.7	78.5	76.7	71.2	61.6	51.2
El Paso, Tex.	64.3	73.1	81.5	83.4	80.8	73.6	63.8	50.6
Fort Davis, Tex.	60.7	68.4	78.3	76.8	73.8	68.2	61.9	43.5
Fort Elliott, Tex.	57.1	69.7	73.7	78.1	76.2	69.4	58.1	50.6
Fort Smith, Ark.	62.8	68.9	77.2	81.5	79	73.4	62.8	47.8
Knoxville, Tenn.	58	66.7	74.2	77.4	75.4	69.9	58.8	51.3
Little Rock, Ark.	63.5	70.2	77.8	81.1	79.1	73.3	63.7	50.9
Memphis, Tenn.	62.5	70.3	78	81.4	79	72.4	62.7	48.8
Nashville, Tenn.	59.6	67.9	75.9	79.6	77.8	70.3	60.3	
Mean	61	69.2	76.7	79.5	77.3	71.3	61.8	49.6
MIDDLE SECTION.								
Auburn, Ala.	63.4	71.4	76.7	78	78.1	74	64	53.8
Augusta, Ga.	64.6	72.5	79.2	82.2	80.2	70.4	64.8	55
Charleston, S. C.	64.4	72.3	79.4	82	80.8	76.1	67.2	58.3
Hatteras, N. C.	56.9	67.2	74	77.6	77.8	74.1	65.1	56.1
Kitty Hawk, N. C.	56	65.9	74.2	78.3	76	73.7	64.1	53.9
Montgomery, Ala.	65.8	73.4	80.4	82.6	80.2	76	65.5	55.6
Palestine, Tex.	66.7	71.6	79	82.3	81.3	75.5	66.8	56.5
Shreveport, La.	67.3	74	81	83.8	82.4	75.7	66.4	55.6
Vicksburg, Miss.	65.9	72.9	79.5	82.4	80.9	75.4	65.9	56
Wilmington, N. C.	60.5	67.2	76.2	79.5	78.4	73.5	62.1	55.6
Mean	63.2	70.8	77.9	80.9	79.6	74.4	65.2	55.6

TABLE 4.—Mean monthly temperature of stations in the cotton belt—Continued.

Station.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.
SOUTHERN SECTION.								
	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
Brownsville, Tex.....	74.4	79.3	82.7	83.8	83.1	79.7	70.1	66.8
Cedar Keys, Fla.....	69.8	75.5	80.1	82	81.8	79.5	72.6	63.5
Galveston, Tex.....	70	76.1	82.3	84.3	83.5	79.3	72.6	62.3
Jacksonville, Fla.....	68.9	72	80.7	82.9	81.7	78.3	70.5	62.5
Mobile, Ala.....	67.1	74.2	80.4	82.6	80.7	74.8	68.2	58.5
New Orleans, La.....	68.9	74.9	80.6	82.7	81.8	78.5	70.4	61
Pensacola, Fla.....	67.7	73.4	79.8	81.4	80.9	77.7	67.8	59.4
Rio Grande City, Tex.....	74.2	80.9	85.5	87.4	86.3	81.6	74.5	64.9
San Antonio, Tex.....	69.4	74.8	81.2	83.5	82.6	77.2	69.5	58.3
Savannah, Ga.....	66.6	73.2	79.6	82.4	79.1	76	66.9	58.6
Mean.....	69.7	75.4	81.3	83.3	82.1	78.2	70.3	61.5

TABLE 5.—Mean maximum temperature of stations in the cotton belt.

Station.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
NORTHERN SECTION.								
	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
Atlanta, Ga.....	71	78.3	84.3	86.7	84.3	78.8	70.5	60.4
Charlotte, N. C.....	70.4	78.9	85.4	87.9	85.2	79.9	71.3	60
Chattanooga, Tenn.....	74.2	79.6	85.3	87.9	85.6	80.3	71.1	59.6
El Paso, Tex.....	80.1	88.9	97.6	98	94.4	86.7	78.2	64.9
Fort Davis, Tex.....	75.1	82.9	90.4	89.2	83.3	79.6	74	62.8
Fort Elliott, Tex.....	70.9	77.3	85.6	90.6	87.8	81.9	70.3	56.3
Fort Smith, Ark.....	74	80.3	87.6	92.6	89.9	84.5	74.5	61.4
Knoxville, Tenn.....	68.3	77.6	84.1	87.1	85	79.9	69.5	57.4
Little Rock, Ark.....	73.3	79.5	86.7	90.1	88.1	82.2	73	60.1
Memphis, Tenn.....	71.5	79.4	87	90.1	87.6	81.2	71.3	59
Nashville, Tenn.....	69.5	78.2	85.3	89.1	86.8	79.7	70.3	57.8
Mean.....	72.6	80.1	87.2	89.9	87	81.3	72	60
MIDDLE SECTION.								
Auburn, Ala.....	72.7	80.9	84.8	84.8	86.8	82.7	74.7	63.8
Augusta, Ga.....	75.3	83.4	89.1	91.8	89.3	84.6	75.2	65.4
Charleston, S. C.....	71.9	79.5	86.4	88.9	87	82.2	74.1	65.6
Hatteras, N. C.....	63.2	72.5	79.2	82.6	81.9	78.8	70.2	61.7
Kitty Hawk, N. C.....	62.7	72.9	80.8	84.5	80.1	79.1	69.6	59.9
Montgomery, Ala.....	76	83.8	89.8	91.9	88.6	85.3	75.5	65.3
Palestine, Tex.....	76.3	81.2	88.4	92	91.3	85.2	77.1	66.1
Shreveport, La.....	77.4	84	91	93.7	92.4	85.2	76.6	65.4
Vicksburg, Miss.....	75.4	82.9	89	91.7	90.2	84.3	75.2	65.4
Wilmington, N. C.....	69.3	76.6	84.4	86.7	85.9	81.1	69.1	64.7
Mean.....	72	79.8	86.3	88.8	87.3	82.8	73.7	64.3
SOUTHERN SECTION.								
Brownsville, Tex.....	82.4	86.2	90.2	91.3	91.3	87.6	83.8	74.9
Cedar Keys, Fla.....	76.1	81.9	86.4	87.9	87.9	86.1	79.2	70.6
Galveston, Tex.....	75.1	81.5	87.4	89.6	88.7	84.1	77.6	67.6
Jacksonville, Fla.....	78	83.6	89	91.1	89.7	85.6	78.3	71.1
Mobile, Ala.....	75.5	83.2	88.8	90.8	88.2	85.7	77	67.4
New Orleans, La.....	76.1	82	87.2	89.1	88.2	84.8	77.3	68.1
Pensacola, Fla.....	74.6	80.1	86.1	87.9	87.6	84.6	75.6	67.6
Rio Grande City, Tex.....	87.8	91.5	96.7	99.2	98	92.1	85.2	74.9
San Antonio, Tex.....	79.7	84.7	91.2	94.1	93.2	86.7	80.1	68.6
Savannah, Ga.....	74.7	81.4	87.5	90.1	87.8	82.9	74.7	67.3
Mean.....	78	83.6	89	91.1	90	86	78.8	69.8

TABLE 6.—*Mean minimum temperature of stations in the cotton belt.*

Station.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
NORTHERN SECTION.								
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Atlanta, Ga.	52.2	59.6	67.2	70	68.4	63.4	53.6	43.4
Charlotte, N. C.	49.4	58.7	66.3	69.3	67.6	62.6	51.8	41.4
Chattanooga, Tenn.	52.2	58.2	66.1	69.2	67.8	62	52.1	41.4
El Paso, Tex.	48.4	57.3	65.7	68.7	67.2	60.4	49.4	37.6
Fort Davis, Tex.	46.3	54	62.2	64.3	62.3	56.8	49.7	38.3
Fort Elliott, Tex.	43.4	52.1	61.8	65.7	64.6	56.9	45.9	30.8
Fort Smith, Ark.	51.7	57.6	66.8	70.3	68.3	62.3	51.1	39.5
Knoxville, Tenn.	47.7	55.8	64.3	67.4	65.8	59.8	48.1	38.2
Little Rock, Ark.	53.7	60.9	68.8	72.1	70	64.4	54.3	42.5
Memphis, Tenn.	53.4	61.1	69	72.7	70.4	63.6	54	42.8
Nashville, Tenn.	49.7	57.5	66.5	70.1	67.7	60.9	50.3	39.8
Mean	49.8	57.5	65.4	69	67.3	61.2	50.9	39.6
MIDDLE SECTION.								
Auburn, Ala.	54	61.9	68.8	71.2	69.4	65.4	53.4	43.7
Augusta, Ga.	53.8	61.6	69.3	72.6	71	66.1	54.4	44.6
Charleston, S. C.	56.9	65.1	66.3	69.3	74.5	70	60.2	50.9
Hatteras, N. C.	50.6	61.8	68.9	72.6	72.7	69.4	60	50.4
Kitty Hawk, N. C.	49.3	58.9	67.6	72	72	68.3	58.6	47.9
Montgomery, Ala.	55.6	63	71.1	73.3	71.7	66.7	55.6	45.9
Palestine, Tex.	57	62	69.7	72.6	71.3	65.9	56.4	46.9
Shreveport, La.	57.3	64	71	73.9	72.3	66.2	56.2	45.7
Vicksburg, Miss.	56.7	63.4	70.5	73	71.6	66.4	56.5	46.7
Wilmington, N. C.	51.7	57.7	67.9	72.2	70.9	65.8	55.1	46.5
Mean	54.8	61.9	69.1	72.2	71.7	67	56.6	46.9
SOUTHERN SECTION.								
Brownsville, Tex.	66.5	72.3	75.1	76.3	74.9	71.9	66.4	58.6
Cedar Keys, Fla.	63.4	69	74.3	77.5	75.6	72.9	66	56.4
Galveston, Tex.	64.9	70.7	77.1	79	78.2	74.4	67.5	57
Jacksonville, Fla.	59.7	60.4	72.5	74.6	73.7	71	62.8	53.8
Mobile, Ala.	58.7	65.1	72.1	74.4	73.2	63.9	59.3	49.6
New Orleans, La.	61.8	67.7	74.1	76.2	75.4	72.1	63.4	53.9
Pensacola, Fla.	60.8	66.7	73.6	74.8	74.2	70.9	62.1	51.2
Rio Grande City, Tex.	60.5	70.3	74.3	75.6	74.6	71.1	63.7	54.9
San Antonio, Tex.	59.2	64.8	71.2	72.9	72	67.7	58.9	48.1
Savannah, Ga.	57.4	65.1	71.7	74.6	70.4	69	59.1	49.9
Mean	61.3	67.2	73.6	75.6	74.2	70.5	62.9	53.3

These tables show a long season of uniformly warm conditions, especially in the middle and southern sections, which are very favorable to the production of cotton.

Table 7 gives the average rainfall, with the number of rainy days and the number of clear days, for the month of May in the three sections of the cotton belt from 1871 to 1891, inclusive. The detailed information for the several stations is not given in the bulletin from which these tables are taken.

TABLE 7.—Average rainfall, average number of rainy days, and average number of clear days for the month of May for the years 1871 to 1891, inclusive.

[These averages were obtained from data furnished by all regular stations throughout the cotton belt.]

Year.	Northern cotton belt.			Middle cotton belt.			Southern cotton belt.		
	Rainfall.	Number of rainy days.	Number of clear days.	Rainfall.	Number of rainy days.	Number of clear days.	Rainfall.	Number of rainy days.	Number of clear days.
	<i>Inches.</i>			<i>Inches.</i>			<i>Inches.</i>		
1871	4.66	12	8	6.12	8	16	4.30	9	9
1872	3.62	10	11	7.78	10	12	2.78	6	10
1873	5.56	12	4	7.63	12	8	8.86	13	7
1874	1.06	6	13	2.97	7	14	2.94	6	17
1875	2.97	12	10	2.79	7	11	3.20	7	12
1876	5.94	10	9	5.24	10	9	3	6	12
1877	1.53	6	14	3	6	15	1.67	6	11
1878	3	11	11	5.07	9	12	4.37	9	9
1879	3.52	8	13	3.54	10	13	3	6	14
1880	4.22	8	13	3.66	9	14	4.86	10	10
1881	3.34	11	10	2.57	8	10	2.40	7	11
1882	5.89	11	10	3.80	8	8	4.40	8	8
1883	3.34	7	15	3.66	6	11	4.32	7	11
1884	5.20	11	11	6.29	8	9	5.24	10	12
1885	4.35	12	11	6.57	12	8	5.40	11	7
1886	2.83	7	13	2.88	6	16	2.08	4	15
1887	3.68	12	11	4.06	11	10	3.90	9	10
1888	3.92	12	10	5.27	11	8	4.54	10	10
1889	2.51	7	15	2.66	6	15	1.08	4	15
1890	4.05	13	14	5.76	10	12	4.24	10	12
1891	2.67	6	13	2.85	6	13	1.92	4	13
Mean	3.71	10	11	4.48	9	12	3.74	8	11

Table 8 gives the normal precipitation, the average number of rainy days, of clear days, and of cloudy days at the several stations of the three different sections of the cotton belt for the months of June, July, August, and September, which, together with the month of May, are the most important months of the crop season.

TABLE 8.—Precipitation for June, July, August, and September in the cotton belt.

Station.	Normal precipitation.				Average number of rainy days.				Average number of clear days.			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
NORTHERN SECTION.												
	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>								
Atlanta, Ga.	4.41	4.63	4.39	4.21	12	10	13.1	9.7	8	8.8	8	12.6
Charlotte, N. C.	4.67	5.86	5.46	3.24	12	12.2	10.6	8.9	8.7	7.8	9.1	10.5
Chattanooga, Tenn.	4.37	3.72	4.16	4.24	14.3	13.1	13.2	10.9	8.8	8.9	8.6	11.3
El Paso, Tex.	.53	2.17	1.87	1.22	4	8.4	9.4	5.3	19.5	13.5	15	16.7
Fort Davis, Tex.	2.09	3.31	4.17	2.90	8.2	10	10.8	7.4	15.7	15.4	14	13.7
Fort Elliott, Tex.	3.18	2.32	3.27	1.77	6.9	5.3	8.3	5.3	13.2	14.5	16.1	17.1
Fort Smith, Ark.	4.27	4.09	3.65	3.61	10	8.7	8.4	8.1	11.6	13.9	15.3	14.9
Knoxville, Tenn.	4.29	4.37	4.28	3.06	13.3	12.7	12.6	9.6	8.4	10.2	10.3	13.5
Little Rock, Ark.	4.39	3.88	3.92	3.23	11.6	10	8.9	8.4	10.1	11.3	14.5	13.4
Memphis, Tenn.	5	3.29	3.82	3.23	11.6	10	9.9	8.6	9.2	11.6	13.7	13
Nashville, Tenn.	4.34	4.54	3.62	2.82	11.2	10.5	9.4	9.3	6.4	8.9	11.2	11.4
Mean	3.77	3.83	3.87	3.14	10.4	10	10.4	8.3	10.8	11.3	12.3	13.5
MIDDLE SECTION.												
Auburn, Ala.	5.28	4.37	4.20	3.29	10.2	10	12.4	7.5	6.4	7.5	9.4	8.9
Augusta, Ga.	4.24	5.17	4.83	3.74	11.3	11.2	10.8	8	8.1	8.8	8.2	10.2
Hatteras, N. C.	4.86	6.33	6.52	6.61	10.6	11.1	13.8	7.8	10.2	11.3	11.2	13.6
Kitty Hawk, N. C.	4.81	5.81	7.48	5.18	10.8	11.4	12.9	5.4	10.6	9.7	8.4	11.5
Montgomery, Ala.	4.92	4.24	3.80	3.11	12.3	12	12	8.6	7.7	7.5	8.3	11.7
Palestine, Tex.	3.51	2.82	2.51	3.21	7.9	7.1	6.7	8.2	8.7	13.9	13	12.9
Shreveport, La.	3.57	3.68	2.05	4.25	8.4	8.7	5.7	8.3	9.3	11.4	13.6	13.9
Vicksburg, Miss.	4.35	4.15	3.50	3.85	10.9	11.3	8.7	9.1	9.3	9.7	11.2	12
Wilmington, N. C.	5.94	7.27	7.80	6.70	12	15.1	13.7	9.8	8.7	8.8	8.5	10.4
Mean	4.60	4.87	4.74	4.43	10.5	10.8	10.6	8	8.7	8.7	10.2	11.6

TABLE 8.—*Precipitation for June, July, August, and September, etc.—Continued.*

Station.	Normal precipitation.				Average number of rainy days.				Average number of clear days.			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
SOUTHERN SECTION.												
	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>								
Brownsville, Tex	3.25	2.22	3.90	7.73	6.9	4.5	7.3	11.5	13.5	15.1	12.4	11.1
Cedar Keys, Fla	6.83	8.68	7.72	5.37	11.3	14.5	13.1	10.1	6.2	7.7	8.7	11.9
Galveston, Tex	5.76	3.04	2.94	7.07	7.2	8.6	10.3	11.7	11.7	13.2	13.3	12.6
Jacksonville, Fla	6.03	6.36	6.80	8.06	14.8	16.7	15.5	14.1	7.7	8.8	8.7	9.1
Mobile, Ala	6.06	6.60	6.41	5.06	12.9	15.1	12.8	9.5	8.1	7	8.1	11.2
New Orleans, La	6.66	6.38	6.02	4.82	13.8	15.8	14.5	10.6	8.1	8	8.1	10.9
Pensacola, Fla	5.85	6.55	8.13	5.25	12.4	14.7	13.6	10	10	9.1	10.5	12.4
Rio Grande City, Tex	2.27	1.29	2.94	3.78	4.8	3.6	4.9	9.4	14.1	19	14.6	11.5
San Antonio, Tex	2.46	2.68	3.45	4.16	6.3	6	6.7	9.7	8.4	10.8	8.7	10.2
Savannah, Ga	6.75	5.34	7.65	5.89	13.1	12.8	13.5	11.5	7.3	7.9	7.7	8.7
Mean	5.18	4.91	5.59	5.71	10.3	11.2	11.2	10.7	9.5	10.6	10	10.9
Station.	Average number of partly cloudy days.				Average number of cloudy days.							
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.				
NORTHERN SECTION.												
Atlanta, Ga	14.6	14.9	15	11.7	7.4	7.3	8	5.7				
Charlotte, N. C	13.3	14.7	12.3	10.8	8	8.5	9.6	8.7				
Chattanooga, Tenn	14.4	14.6	15.4	12.1	6.1	6.7	7	6.6				
El Paso, Tex	9.5	14.8	11.7	8.9	1	2.7	4.3	4.4				
Fort Davis, Tex	12.5	11.6	12.6	10.5	1.8	4	4.4	5.8				
Fort Elliott, Tex	12.8	13.1	9.9	9.2	3.7	3.4	5	3.7				
Fort Smith, Ark	13	12.2	9.6	8.6	5.4	4.9	6.1	6.5				
Knoxville, Tenn	15	14.5	14	9.5	6.6	6.3	6.7	7				
Little Rock, Ark	14.6	14.1	12.4	11.6	5.3	5.6	4.1	5				
Memphis, Tenn	14.7	13.8	11.7	10	6.1	5.6	5.6	7				
Nashville, Tenn	17.1	16.1	14.2	11.6	6.5	6	5.6	7				
Mean	14.6	14	12.6	10.4	5.2	5.5	6	6.1				
MIDDLE SECTION.												
Auburn, Ala	14	16.6	15	13.3	9.6	6.9	6.6	7.8				
Augusta, Ga	14.7	14.6	15	12.1	7.2	7.6	7.8	7.7				
Hatteras, N. C	6	13.4	11.8	11.2	13.8	6.3	8	6.2				
Kitty Hawk, N. C	13.5	15.3	14.9	11.3	5.9	6	7.7	7.2				
Montgomery, Ala	13.5	15.8	16.3	10.7	8.8	7.7	6.4	7.6				
Palestine, Tex	16.1	13.6	14.8	10.5	5	3.5	3.2	6.6				
Shreveport, La	15.7	15.1	13.9	9.7	5	4.5	3.5	6.4				
Vicksburg, Miss	15	15.1	15.1	10	5.7	6.2	4.7	8				
Wilmington, N. C	14.4	14.4	13.5	10.9	7.9	7.8	9	8.7				
Mean	13.6	14.8	14.4	11	7.6	6.2	6.3	7.3				
SOUTHERN SECTION.												
Brownsville, Tex	12.5	12.8	15.1	12.8	4	2.5	3.5	6.1				
Cedar Keys, Fla	16.6	14	13.9	12.9	7.2	9.3	8.4	5.2				
Galveston, Tex	13.8	14.1	12.9	10.7	4.5	3.7	4.8	6.7				
Jacksonville, Fla	15	16.1	16.4	12.2	7.3	6.1	5.9	8.7				
Mobile, Ala	15	16.3	15.9	12	6.9	7.7	7	6.8				
New Orleans, La	15.5	17.4	17.9	13.1	6.4	5.6	5	6				
Pensacola, Fla	14.6	15.8	14	12.3	5.4	6.1	6.5	5.3				
Rio Grande City, Tex	12.1	8.7	10.7	12.1	3.8	3.3	5.7	6.4				
San Antonio, Tex	16.1	16.2	18.3	11.8	5.5	4	4	8				
Savannah, Ga	14.9	16.2	15.3	11.7	7.2	6.9	8	9.6				
Mean	14.6	14.7	15	12.1	5.8	5.5	5.8	6.8				

Little comment is here made upon the data contained in these tables. They are but broad, general statements of the climatic conditions, which can be used for general comparisons and as a basis for other more detailed work.

SOIL.

Cotton is at present cultivated with more or less success on nearly all kinds of soils within the region in which the climatic conditions are favorable to its growth and development. It is grown alike on light sandy soils, on loams, on heavy clay soils, and on bottom lands, but not with equal success on all of these different types of soil. On the sandy uplands the yield of cotton is usually very small; on clay lands, especially in wet seasons, the plants attain large size, but yield a small amount of lint in proportion to the size of the plants. This is also likely to be the case on bottom lands. The safest soils for the crop are medium grades of loam. On the bottom lands in very favorable seasons the crop often produces a very large yield, but it is not so certain, and in unfavorable seasons the plants are liable to disease and to insect ravages.

It becomes important for the cotton planter to understand the soils of his farm in order to get the greatest possible advantage from the soils adapted to cotton and to appreciate the fact that he can not hope to compete successfully in the production of cotton on other kinds of land. It is the purpose of this chapter to summarize our present knowledge of the relations of soils to crops from the investigations which have been carried on in this country and abroad, not only to concentrate the light upon this subject for immediate benefit in its application to the problems of present interest to the cotton planter, but to stimulate interest in this subject, which presents a very promising field for investigation.

The study of soils is naturally divided into two parts—(1) the soil considered merely as a source of food supply for plants and (2) the study of the physical conditions in the soils, especially of moisture and heat, which are equally essential for the growth and development of plants.

CHEMICAL PROPERTIES OF SOILS.

The chemistry of soils has been very earnestly studied in the past fifty years. It was once very generally believed by agricultural chemists that the chemical analyses of any particular soil and plant would show what might be lacking in the soil for the production of a normal crop of the plant. Later investigations have dispelled this idea, and have shown that there is no simple relation between the chemical analysis of a soil and the crop-producing power. This is especially marked in the case of nitrogen, phosphoric acid, potash, and lime, which experience has taught us to apply to the soils in the form of fertilizers. That these fertilizers have been of great and undoubted value in the increased production of crops no one can for a moment doubt, but the effect of these fertilizers on the soil in increasing the yield of crops, and the real principle upon which we should apply them to the land is a subject of

considerable doubt and a matter of very diverse opinions among scientific men.

Soils, to a depth of 1 foot, rarely contain less than 0.05 per cent each of phosphoric acid, potash, and lime, which corresponds to about 1 ton of these substances per acre, and they usually contain from two to twenty times this amount. A soil, however, containing as much as 10 tons of phosphoric acid or of potash or of lime per acre may be naturally unproductive or may be readily exhausted by injudicious methods of cropping and cultivation. Crops remove but a very small amount of mineral food—so little, indeed, that the loss can not be detected by the most careful chemical analysis of the soil after a large crop has been removed. It has been repeatedly shown that very barren soils often contain as much plant food as others which are considered fertile. It is strange indeed that the application of a fertilizer containing no more than 20 pounds per acre of phosphoric acid or of potash to a soil which, to a depth of 1 foot, already contains from 2,000 to 40,000 pounds, should make the difference between a poor and a large crop. It is no unusual thing to find in the experience of farmers and in the careful experiments conducted at the experiment stations that the increased crop due to this addition of fertilizing material contains more plant food than is contained in the fertilizer which has caused the increase.

It is commonly believed now by agricultural chemists that the reason small quantities of fertilizers have such an effect upon soils containing such enormous quantities of these same ingredients is that only a very small portion of the plant food in the soil is in a condition to be readily available to plants, as by far the larger proportion of the plant food is in the form of minerals which the plants can not readily assimilate.

Recent investigations have therefore been turned to the consideration of the amount of food material in the soil which is readily available to plants. Two methods have given considerable promise of valuable suggestion as to the amount of available plant food in soils. One is based upon the assumption that the available plant food is combined with the partially decomposed organic matter or humus in the soil, and that if this humus is extracted and an analysis made of it the results will show the amount of the food material in the soil readily available to plants. This idea has been strongly advocated by Grandeaun and has been developed in this country with valuable results by Hilgard¹ and Snyder.²

For years an effort has been made to find a solvent of such a character and concentration as shall dissolve out of the soil itself about the same amount of plant food that a plant would extract through its roots during its season of growth. Dyer³ has made a very thorough and

¹ California Sta. Rpt. 1891-92, p. 241.

² Minnesota Sta. Bul. 41.

³ Jour. Chem. Soc., 1894, p. 115 (E. S. R., 5, p. 1013).

systematic study of the soils of some of the experimental plats at Rothamsted, and has obtained some exceedingly interesting and promising results. He used as a solvent a 1 per cent solution of citric acid, which has about the same acidity as the juices expressed from the roots of a large number of plants which he examined. Citric acid was selected because it is an organic acid very commonly present in plants, and is easy to obtain in a comparatively pure state. This dilute acid was allowed to act on the soil for a considerable time at a certain temperature, the soil and solvent being occasionally shaken.

The amount of plant food extracted in this way from the soil was estimated, and was assumed to be the amount of food material in the soils available to plants. Very striking relations were shown to exist between the matters extracted by this process and the crop yields from the different plats.

A great deal of light has been thrown upon the chemical constitution of soils by these investigations, but the point is not reached at which the kind of crop best adapted to a given soil or the additions of plant food necessary to make the soil suitable for crops to which it is not naturally adapted can be predicted with certainty from a chemical analysis of soil and crop. This is undoubtedly due in large part to the fact that the agricultural chemist has paid too little attention to the other conditions of growth, especially to the physical conditions of the soil, which are of equal importance with the chemical composition of the soil in determining crop production.

A very large amount of work has been done in this country in the investigation of the chemical composition of soils of the cotton region. Very valuable and suggestive work has been published in the reports of the Kentucky Geological Survey, in the reports of Professor Hilgard on the agriculture of Mississippi and California, and especially in the elaborate summary of the work of Hilgard and others in the Tenth Census.¹ This latter report describes in great detail the soils of all of the principal agricultural regions of the cotton belt, and gives a great many analyses showing their chemical composition as determined by digestion with strong hydrochloric acid. (See p. 164.)

The limits of this chapter permit of only the most general statements as to the results of the vast amount of work done prior to the publication of the Tenth Census and of the special investigations undertaken for the Tenth Census itself on the chemical composition of soils adapted to cotton. Hilgard states,² as a result of his investigations and that of his collaborators in this exhaustive research, that as a rule the relative proportions of phosphoric acid and of lime seems to govern the productiveness of our virgin soils. A soil containing only 0.05 per cent of phosphoric acid must be regarded as seriously deficient in this element unless it contains a large amount of lime. In sandy loam soils 0.1

¹ Tenth Census of the U. S., 1880, Vols. V and VI, Cotton Production, parts 1 and 2.

² Tenth Census of the U. S., 1880, Vol. V, Cotton Production, part 1, p. 78.

per cent, when accompanied by a fair supply of lime, gives a fair productiveness for from eight to fifteen years. With a deficiency of lime, however, twice that amount will only serve for a similar time. The maximum amount of phosphoric acid found in a pine upland soil by his method of analysis is about 0.25 per cent in the splendid table-land soils of west Tennessee and Mississippi. In the best bottom soils, or buckshot soils, of the Mississippi Valley, 0.3; in that of the black prairie of Texas, 0.46, and in a red-clay soil from Tennessee, 0.563 per cent. This latter figure would imply the presence of 22,000 pounds of phosphoric acid per acre to a depth of 1 foot, soluble in the acid of the strength used in the chemical analyses.

Virgin soils containing less than 0.06 per cent of potash may be usually assumed to be deficient in available potash, and an application of potash to such soils may be expected to give beneficial results. Sometimes, however, a soil very rich in lime and phosphoric acid shows good productiveness despite a very low potash percentage. The amount of potash in heavy clay upland soil and clay loams ranges from about 0.8 to 0.5 per cent, in lighter loams from 0.45 to 0.30, in sandy loams it falls below 0.3, and in sandy soils of great depth it may fall below 0.1 per cent and still give good productiveness and durability, depending somewhat upon the amount of lime and phosphoric acid within the soil. It will thus be seen that the percentage of potash varies somewhat with the amount of clay. The buckshot soil of the Mississippi bottom contains 1.3 per cent of potash and 1.4 per cent of lime and is jet black with humus and may well serve as the type of a fertile soil. Hilgard states that in his experience few of the soils of the South contain less potash than the quantities above reported and that potash manures are not usually necessary for the exhausted soils of the South. He also states that the universal preference given to phosphoric and nitrogenous fertilizers in the West and South is in accord with this inference.

Hilgard states as a result of his experience that 0.1 per cent of lime in the lightest sandy soils gives character to the native timber growth. In clay loams there should be not less than 0.5 per cent, and the amount may rise advantageously to 1 or even 2 per cent.

These conclusions of Hilgard as the result of the extensive investigations for the Tenth Census still stand, and are likely to stand for a long time to come, as the standards by which we will compare the chemical composition of the soils in this country. They are very general, but it is not possible at present to give more specific statements. But little work has been done upon the chemical composition of the soils of the cotton belt since the completion of the investigations made for the Tenth Census.

More recently Pagnoul¹ states as a result of his own experiments, and from the experiments of Dehérain, Joulie, and Dellisse, that a soil

¹Terres Arables du Pas-de-Calais, Arras, 1894 (E. S. R., 6, p. 118).

containing less than 0.1 per cent of phosphoric acid will probably be deficient in that substance and will be benefited by the application of phosphates. Miintz points out that this limit should not be arbitrarily fixed, as it would depend largely upon the form of combination of the phosphoric acid in the soil. In regard to the form in which phosphoric acid should be applied, it is stated that if the soil is calcareous superphosphates can be used with advantage; if the soil contains less than 0.1 per cent of lime, superphosphates are apt to be injurious and a phosphate containing free lime, such as Thomas slag, should be used. Precipitated phosphates are well adapted to the soils which need phosphoric acid, but produce their best results on soils which contain smaller amounts of lime. Natural phosphates are used to the best advantage on humus soils when applied in a very finely ground condition. The author states as a result of his investigations that a soil containing 0.25 per cent of potash is not likely to respond profitably to an application of potash salts.

The normal proportion of nitrogen in good soils is stated to be about 0.1 per cent. Whether soils containing as much nitrogen as this will be benefited by an application of nitrogenous fertilizers will depend largely upon the condition of the nitrogen in the soil and upon the demands of the plant. When the amount of nitrogen is below this limit nitrogenous fertilizers are considered almost always indispensable.

These views as to the chemical composition of soils and their relation to plant growth represent the views held at present both in this country and abroad. They are the results of a vast amount of chemical investigation. It will be seen that they are very general and that no specific deductions can be drawn from the chemical analysis of a soil alone.

PHYSICAL STRUCTURE OF SOILS.

In the preceding section the results of the chemical investigations of soils have been given as these bear upon crop production. It has been shown in the first place that the total amount of plant foods in the soil has no simple or direct bearing upon the relation of soils to crop production. It is very generally believed, however, as a result of the investigations in this country and abroad, that fertile soils should have a certain quantity of each of these plant foods as determined by the extraction of the soil by strong acids. If the amount falls below the limits which have been assigned, experience has shown that in most cases the soils will respond to fertilizers or manures containing the elements which are thus shown to be deficient in the soil. But occasionally very poor, worn out, and exhausted soils contain as much of these plant foods as would correspond with the arbitrary limits which have been set for soils of average fertility. It has been stated likewise that promising investigations are being carried on with different solvents, and that it is believed by many that it will be possible to find a solvent

of a nature and strength which will indicate very clearly the amount of plant food in the soil which is available to plants.

We come now to a consideration of the physical texture and structure of soils and especially to the conditions of moisture they maintain, which have a most important bearing upon crop production, and which undoubtedly are often of such influence that they completely overshadow in importance the chemical composition of the soil.

The classification of soils into sandy, sandy loam, loam, clay loam, clay, and bottom lands has a very distinctive and important meaning to the farmer, for he recognizes certain properties characteristic of each of these classes of soils and has learned from experience to expect certain results.

On the light, sandy uplands the yield per acre is almost invariably small; on stiff clay lands and on bottom lands, especially in wet seasons, the plants are inclined to make an excessive growth of the leafy parts and to put on little fruit in proportion to the size of the plants and the crops to be late in maturing. It is also a recognized fact and a matter of wide experience that plants growing on some of these typical soils are much more subject to diseases and to insect ravages under unfavorable climatic conditions than on other soils. The safest soil for cotton is found to be a medium loam, although, as stated elsewhere, in favorable seasons and under favorable conditions very large yields are obtained from the heavier clay soils and on bottom lands.

The texture of the soils, therefore, or the relative amount of sand and clay, has an important bearing on crop production, as has been shown in the experience of farmers throughout the cotton belt. It remains to be seen what these differences are which are dependent upon the relative amount of sand and clay, which the farmer can recognize at a glance, as he can not recognize differences in the chemical composition of the soil.

The first thing which is very apparent in the consideration of this subject is that the character of the season, and especially of the amount and distribution of the rainfall, has a very marked and important influence upon the yield of cotton on all of these different types of soil. It is no unusual thing for a cotton crop on a heavy clay or rich bottom land to be so badly diseased or to be so injured by insect ravages as to cause an entire failure of the crop, or to be so delayed in maturing, by reason of unfavorable climatic conditions and rank vegetative growth, that the crop does not mature before frost. In more favorable seasons the yield from these same lands may be enormous. Every farmer also recognizes when he puts in his crop the great uncertainty as to the yield, and it is no uncommon thing for the yield of cotton for an entire State to be double one year what it was the previous year. It is likewise a matter of very common experience that the cotton in one field or tract of land will be much more affected by unfavorable

climatic conditions than the crop in an adjacent field of perhaps a different character of soil.

We see here an indication of the great influence the conditions of rainfall and moisture have upon the cotton crop, and we have indications also that these different types of soil maintain very different conditions of moisture for the plants. It may be said, in fact, that while climatic conditions determine the general distribution of plants—make it impracticable, for example, to grow cotton in a northern latitude—the texture of the soils, or the relative amount of sand and clay they contain, and the relation of these differently textured soils to moisture largely determine the local distribution of plants and explain why some soils are adapted to cotton, wheat, tobacco, or to truck farming, and why other soils are not so well adapted to these crops.

As a rule, the relative amount of moisture maintained by different soils for crops under normal conditions depends upon the resistance the soil offers to the descent of the rainfall.

The actual resistance, and therefore the relative amount of moisture, maintained by different soils depends upon the amount of space in the soils for the water to enter; upon the number of grains of sand, silt, and clay, for this will determine how much the space is divided up; upon how these grains are arranged, for this will have an influence upon the resistance or the friction the soil offers to the descent of the rainfall; upon the amount of organic matter in the soil, and upon the depth of the soil.

Soils contain, as a rule, about 50 per cent by volume of empty space; that is, in 1 cubic foot of soil there will be one-half cubic foot of space into which water or air can enter. In a sandy soil this space will not be divided up so much as in a clay soil; the sand having fewer grains the spaces between the grains are larger, so there is less friction and the water moves downward more quickly. These sandy soils will not, therefore, maintain so much moisture for the plants. The particles of clay soils, on the other hand, are so exceedingly minute, and there are such a vast number of them in the soil, that the spaces between them are exceedingly small and offer a great resistance to the descent of rain, so that the water moves very slowly and a large amount is maintained for the plants. A strong clay soil will usually contain three or four times as much water as a sandy soil, and this has a very important effect upon the growth of cotton.

Advantage is taken of this fact in greenhouses, but in nature, of course, we can not control the conditions. In the latter case we must take the amount of rain which falls, but our different soils being so different in texture and in the resistance which they offer to the descent of the rainfall, maintain quite as different conditions of moisture as are supplied in practice under artificial conditions of greenhouse culture. Light sandy soils, being moderately dry, force plants to an early maturity, and these soils are used at present for the very

profitable truck farming which has developed into such an important industry in recent years. Such soils are not adapted to wheat or grass, not necessarily because they are deficient in any particular food required for these crops, but because the dry conditions force the plants to an early maturity and the yield per acre is small. Clay soils, on the other hand, are adapted to wheat and grass, because they maintain uniformly moist conditions and the plants have a slow and prolonged growing period before it is time to mature seed. Clay soils are not adapted to early truck, because the crops are so late in maturing that they lose the advantage of the high market prices.

The resistance or the friction in the soil determines the proportion of the rainfall which will be held back for the use of plants, and determines largely the amount of moisture which different soils maintain. There must, however, be some automatic power to move this water from place to place in the soil and deliver it to the roots of plants as it is needed. This power exists in the soil in the force of surface tension, or, as it is more commonly called, capillary force, which may move water in any direction in the soil, either up or down or laterally.

Fertilizers have an important effect upon this force of surface tension. Lime, kainit, salt, plaster, and acid phosphate increase the surface tension and therefore increase the force which moves water to the plant. This probably explains many facts commonly met with in practice.

A cotton soil should maintain very uniform conditions of moisture, for any marked or sudden variation, especially during the growing period, is apt to affect the vitality of the plant and have a marked effect upon the development of the crop. During the early growing season of the plant, up to the first of August, the soil should be continuously moist, but not wet. A sandy soil, as a rule, is not sufficiently retentive of moisture, and the supply of moisture is so inadequate that the plants are small and are forced to an early maturity before they have gathered sufficient food material for a normal crop. On the other hand, a clay soil or a bottom land is liable to maintain too much moisture, and the plant takes on an excessive growth. If this condition is checked at the proper time and the plant is induced to mature fruit, the yield may be very large, but if this condition continues and the soil remains continuously moist after the first of August, the plants develop in a very luxuriant way, but with little tendency to put on fruit. Such soils may be greatly benefited by underdrainage, whereby the excess of water is artificially removed from the soil. This excessive growth may be checked also by fertilizers, especially by heavy application of phosphoric acid, which has a tendency to check the vegetative growth and hasten the maturity of the plant.

The safest soil for the cotton crop is a deep loam, naturally well drained, but sufficiently retentive of moisture to maintain a uniform supply throughout the entire growing season.

The following is Hilgard's description of the famous buckshot soil of Louisiana, which is justly claimed to be the finest type of cotton soil in this country:

The buckshot soil, in its store of plant food of all kinds, stands preeminent above all of the rest of the soils and well deserves its reputation of being the most productive and tillable soil in the great bottom. Unlike many other clay soils, it may be tilled at any time when the plow can be propelled through it, because on drying it crumbles into a loose mass of better tilth than many elaborately tilled upland soils. It is so deep that the deepest tillage, even by a steam plow, would not reach beyond the true soil material. Its high absorptive power secures crops against injury from drought. Two bales of lint per acre can be produced on these soils with fair cultivation and good seasons.

In South Carolina the ridge lands and the soils of the Red Hill formation, covering an extensive area in the central and eastern portions of the State, are types of the most productive and most certain cotton soils, under good treatment, of any in the State. These soils, which may be considered a type of the finest cotton soils of that locality, contain from 25 to 30 per cent of clay and 40 per cent of silt. In the North this would make a very fair quality of wheat land. These soils maintain on an average during the growing season about 10 or 12 per cent of moisture for the cotton crop.

The Sea Island cotton is best adapted to a very different kind of soil. The best soils for this variety are light, fine-grained, sandy soils, containing from 4 to 8 per cent of clay, from 4 to 6 per cent of silt, and from 75 to 90 per cent of fine sand. Soils of this character from James Island maintained during two growing seasons about 5 per cent of moisture and are very different from the best type of soils adapted to the upland cotton.

The foregoing is a concise statement of the present views of the relation of climatic conditions and of soils to cotton production rather than an attempt to describe the individual soil formations. In the cotton report of the Tenth Census the principal soil formations of the cotton-producing States are very elaborately described, and form the basis for very valuable investigations.¹

It is believed that this discussion of the principles will be of more value than a description of the agricultural features of the different soils of the cotton belt, as it is more suggestive both to the practical farmer in his study of the best methods of dealing with his land and to the investigator who wishes to continue the study of the important problem presented in the relation of climate and soils to cotton production.

Comparatively little work has been done in this country upon the physical properties of the soils of the cotton belt. Quite a number of mechanical analyses of soils were made by Hilgard's method for the report on cotton for the Tenth Census, but there is little attempt at an interpretation of these results, and in all that mass of literature

¹ See also chapter on culture, p. 225.

very little attention has been given to the physical properties of the soils. Very little work has been done since then upon the study of the structure or physical properties of the soils of the cotton belt.

TYPICAL SOILS OF THE COTTON BELT.

As already noted, chemical examination of the soils of the cotton region has been more complete than physical studies. The following tables, compiled from Hilgard's report in the Tenth Census, referred to above, give the chemical analyses of representative samples of subsoil from the typical soil areas in all the States in which cotton is extensively grown. For a complete compilation of analyses the reader is referred to the original report.

Classification of the typical soil areas of the cotton States.

[The numbers refer to samples in the accompanying tables of analyses.]

ALABAMA.

Middle division.

Metamorphic region:

Red lands.

Gray lands.

Coosa Valley region:

Flatwoods.

Brown-loam and red-clay lands.

Gray cherty lands.

Northern division.

Coal Measures region.

Tennessee Valley region:

The barrens.

The red valley lands.

Tennessee Valley region—Continued.

Sandy land of the Little Mountain range.

Southern division.

Oak and pine uplands region:

Oak and hickory uplands, with short-leaf pine.

Gravelly hills, with long-leaf pine (3, 9, 20).

Oak and hickory uplands, with long-leaf pine (140, 94, 92).

Central or upper prairie region:

Black prairies or canebrake (30, 16).

Central or upper prairie region—Cont'd.

Hill prairies (13).

Blue-marl lands.

Post-oak flatwoods region (25, 17).

Lime hills or lower prairie region (139, 90).

Long-leaf pine region (88).

Alluvial region.

ARKANSAS.

Alluvial lands:

Mississippi and St. Francis alluvial region (219).

Arkansas River bottom (275, 284, 390, 427, 416).

White River lands (246, 384, 441, 233).

Saline River lands (337).

Red River bottom lands (359).

Poplar ridge lands east of White River (222, 447, 434).

Gray-silt prairies of eastern Arkansas (323, 434, 468).

Yellow loam and sandy pine-hills region:

Gray sandy (350).

Black prairie of the Southwest (328).

Red-loam region, rocky, and hill lands:

Gray and red loam timbered lands (314, 393, 317, 302).

Western and central red-loam prairie region (353).

Northwestern red prairie (254).

Metamorphic soils (402).

Northern barrens and hills region:

Siliceous lands of chert, sandstone, and limestone (287, 308, 293, 242).

Barrens and cherty magnesian limestone lands (266, 257, 250).

GEORGIA.

Northwest Georgia:

Gray sandy lands of the metamorphic border.

Flatwoods.

Red-clay lands.

Gray siliceous soils of the ridges.

Brown and red loams (517).

Yellow-clay lands.

Sandy table or mountain lands.

Alluvial lands.

Metamorphic or mineral region (Blue Ridge):

Gray sandy lands (212, 82).

Red lands.

Gray granitic lands (288).

Metamorphic or mineral region (Blue Ridge)—Continued.

Flatwoods.

Central cotton belt:

Sand and pine hills or border region.

Oak, hickory, and pine uplands (165, 182).

Red-clay hills.

Long-leaf pine and wire-grass region:

Lime-sink or clay lands (500).

Sandy pine barrens (509).

Pine and palmetto flats.

Coast region:

Savanna lands.

Live-oak and coast lands (511).

LOUISIANA.

Alluvial region:

Alluvial region north of Red River (238).

Red River bottom region (39).

Alluvial region south of Red River.

Tidewater region.

Marsh lands.

Bluff region.

Attakapas prairie region:

Black calcareous prairie (230).

Brown-loam prairie.

Gray silt, or pine prairies (195).

Long-leaf pine region:

Pine flats.

Pine hills (134).

Anacoco prairie.

Central prairie region.

Oak-upland region:

Red lands (231, 184).

Brown loam.

Pale loam (232).

Pine flats. •

MISSISSIPPI.

The northeastern prairie region:

Rotten limestone prairie region—

Black prairie (172, 125).

Black-jack prairie.

Bald prairie (175).

Ridge soils (141).

Hickory hummocks (273).

Sandy upland ridges.

Bottom soils (177).

The Pontotoc ridge.

The flatwoods region:

Post-oak flatwoods (230).

White-oak flatwoods (147).

Yellow-loam or oak upland region:

Flatwood hills (119).

Short-leaf pine and oak uplands (142).

Red lands (246).

Sandy oak uplands (228).

Brown-loam table lands (216).

Bottom soils of the yellow-loam region (156).

The alluvial region of the Mississippi:

Yazoo basin.

Dogwood ridge (396).

Sunflower basin (376).

Deer Creek region (390).

The cane-hills region:

Bottom or valley soils of the region (117).

Oak uplands belt (237, 116).

Central prairie region:

Soils of the central prairie region—

Black prairie soils (188, 210, 44, 40).

Gypseous and hog-wallow prairie soils (242, 38).

Sandy ridge lands.

Marls of the central prairie region.

Long-leaf pine region:

Long-leaf pine hills (205, 292, 361, 181).

Pine-flats region.

Coast marshes (214, 88, 90).

NORTH CAROLINA.

Seaboard region (21, 25).

Long-leaf pine region:

Sandy pine barrens.

Level and rolling upland pine woods (13, 17, 37).

Long-leaf pine region—Continued.

Pine flats (11).

Oak upland region (2).

Transmontane region.

SOUTH CAROLINA.

Coast region.
Lower pine belt.
Upper pine belt.
Red hills.

Sand hills.
Metamorphic region.
Piedmont region.

TENNESSEE.

Mississippi bottom.
Upland of west Tennessee:
Bluff region (16, 17).
Brown, loam table-lands (235).
Western valley of Tennessee River.

Highland rim.
Central basin:
Central limestone soils (2, 8).
Orthis limestone lands (12, 14).
Mulatto lands (10).

TEXAS.

The timbered upland:
Short-leaf pine (1).
The red hills (4, 6).
Oak and hickory uplands (3).
Prairies of the timbered region—
Sandy prairies (7).
Brown-loam prairies (34).
Long-leaf pine region.
The cross timbers (upper and lower).
Southern coast prairies.
East of the Brazos (9, 10).
West of the Brazos (11).
Southwest prairie and sandy deserts.
Central black prairie region:
Hog-wallow.
Black sandy prairies (12).

Central black prairie region—Cont'd.
Black waxy prairies (15, 14).
Northwestern red-loam region (16).
Western and northwestern region:
Gypsum region.
Llano estacado or staked plain.
Mountainous region of west Texas.
Alluvial or river lands:
Red River lands (40).
Sabine and Trinity river lands.
Brazos River lands ("sugar bowl")
(19).
Colorado, San Saba, Guadalupe, San
Antonio, Neuces, and Rio Grande
river lands.

Analyses of typical soils of the cotton States.

No.	Kind of soil.	Locality.	Depth at which sample was taken.	Soluble silica.	Alumina.	Oxid of iron.	Potash.	Phosphoric acid.	Lime.
	ALABAMA.								
	<i>Oak and pine uplands.</i>								
3	Upland pine-woods soil ...	Prattville.....	In. 8	Per cent. 1.39	Per cent. 0.60	Per cent. 0.74	Per cent. 0.04	Per cent. 0.06	Per cent. 0.07
9	Alabama River hummock soil.	Montgomery.....	8	6.04	4.84	5.36	.34	.14	.14
20	Warrior River hummock soil.	Tuscaloosa	6	6.52	5.18	4.40	.25	.27	.47
140	Lime-hills soil.....	Wilcox County	8	1.13	7.77	5.55	.17	.23	.18
94	Sandy upland soil (cult.)..	Barbour County	12	1.91	1.39	.60	.....	.03	.01
92	Alabama River second-bottom soil.	Wilcox County	9	3.27	2.29	1.78	.17	.20	.22
	<i>Central prairie region.</i>								
30	Black prairie soil.....	Livingston	10	17.92	12.42	6.94	.44	.10	1.96
16	do.....	Union Springs.....	12	10.43	11.49	7.86	.29	.51	.98
13	Upland sandy loam soil	do.....	6	1.88	1.26	.88	.21	.06	.08
	<i>Post-oak flatwoods region.</i>								
25	Post-oak flatwood soil.....	Livingston	10-48	10.05	10.20	6.54	.30	.21	.20
17	Post-oak prairie soil.....	Union Springs.....	12	11.98	6.02	6.98	.21	.25	.37
	<i>Lime-hill region.</i>								
139	Black shell prairie soil	Washington County ..	8	1.75	5.16	5.42	.55	.37	29.20
90	Upland brown-loam soil....	Gosport	10	3.09	3.40	2	.14	.12	.10
88	Upland pine-woods soil....	Andalusia	10	1.58	3.02	1.14	.17	.11	.09

Analyses of typical soils of the cotton States—Continued.

No.	Kind of soil.	Locality.	Depth at which sample was taken.	Soluble silica.	Alumina.	Oxid of iron.	Potash.	Phosphoric acid.	Lime.
	ARKANSAS.								
	<i>Alluvial lands.</i>								
219	Black bottom	Crowleys Ridges, Greene County.	In.	Per cent. 98	Per cent. 0.40	Per cent. 1.01	Per cent. 0.13	Per cent. 0.68	Per cent. 0.05
275	Arkansas bottom waste...	Van Buren.....		80.60	.....	.....	.58	.21	.53
284	Sandy loam.....	do.....		89.90	3.09	2.36	.31	.16	.17
390	Arkansas bottom.....	Perry County.....	9-12	93.52	.61	1.54	.21	.18	.22
427	Stiff chocolate-colored soil	Jefferson County.....		71.17	10.34	7	1.01	.46	.75
416	Arkansas River bottom cotton soil.	Arkansas County.....		81.24	6.09	4.64	.71	.22	.54
246	Oil trough bottom soil.....	Independence County.....		83.73	5.29	3.31	.44	.22	.36
384	Bottom soil.....	Batesville.....		91.59	2.81	2.12	.21	.21	.19
441	Sandy loam.....	Phillips County.....		90.40	3.39	2.71	.30	.26	.47
233	Cache River bottom.....	Jackson County.....		91.63	2.19	2.07	.30	.19	.17
337	Second bottom soil.....	Saline County.....		90	1.19	5.27	.21	.18	.09
359	Stiff Red River bottom.....	Miller County.....		79.42	4.84	4.72	.53	.16	2.25
222	Sandy soil.....	Crowleys Ridge.....		91.87	1.17	1.96	.21	.12	.15
447	Hill land.....	do.....		91.79	3.36	2.29	.19	.19	.25
434	Little Prairie soil.....	Moreau.....		88.40	4.89	2.79	.29	.13	.....
	<i>Gray silt prairies of eastern Arkansas.</i>								
323	Soil of Grand Prairie.....	Prairie County.....		92.33	1.52	2.02	.13	.13	.03
434	Soil of Little Prairie.....	Lee County.....		88.40	4.89	2.79	.29	.13	.....
408	Gray silt prairie.....	Arkansas County.....		86.46	4.91	3.97	.17	.12	.05
	<i>Yellow loam and sandy pine hills region.</i>								
350	Pine hills soil.....	Union County.....	10	92.12	2.94	1.87	.10	.06	.04
328	Black calcareous prairies.....	Hempstead County.....		35.14	5.24	2.54	.31	.09	28.13
	<i>Red-loam region, rocky and hill lands.</i>								
314	Sandy soil.....	Pulaski County.....		90.91	3.46	2.27	.09	.06	.02
393	Brownish-gray soil.....	Yell County.....		90.84	3.19	2.94	.16	.21	.02
317	Gray sandy soil.....	Pope County.....		90.31	3.09	3.05	.15	.18	.06
302	Red ferruginous soil.....	White County.....		88.85	4.38	2.99	.19	.10	.05
353	Red sumac prairie.....	Sebastian County.....		83.24	4.51	6.94	.21	.21	.07
254	Prairie soil.....	Marion County.....		88.96	3.34	2.86	.29	.14	.17
402	Granite soil.....	Pulaski County.....		87.34	4.64	4.39	.23	.14	.12
	<i>Northern barrens and hills region.</i>								
287	Sandy soil.....	Benton County.....		92.20	1.19	2.56	.19	.04	.03
308	Brush Creek barrens.....	Madison County.....		91.85	2.33	2.16	.13	.19	.07
293	Brownish-colored soils.....	Newton County.....		90.85	3.14	2.46	.17	.08	.11
242	do.....	Izard County.....		85.08	4.79	4.49	.37	.19	.14
266	Barrens soil.....	Fulton County.....		77.35	7.24	5.36	.70	.17	.24
257	Upland siliceous soil.....	Marion County.....		90.80	3.34	2.67	.25	.12	.11
	GEORGIA.								
	<i>Northwest Georgia.</i>								
517	Dark mulatto soil.....	Cedartown.....	8	5.21	9.72	6.23	.33	.04	.29
	<i>Metamorphic region.</i>								
212	Gray sandy soil.....	Clarksville.....		1.83	2.60	.85	.12	.04	.02
82	Sandy soil.....	Douglas County.....	3	2.57	3.18	2.66	.16	.30	.13
288	Mulatto soil.....	Jonesboro.....	6	3.44	3.05	2.17	.24	.23	.08
	<i>Central cotton belt.</i>								
165	Open pine woods.....	Thomasville.....	6	1.04	1.58	.93	.03	.01	.05
182	Hummock soil.....	Decatur County.....		2.37	1.09	1.13	.07	.24	.05
166	Red-hills soil.....	Stewart County.....	6	2.71	10.60	4.05	.13	.07	.22

a Oxid of manganese and iron.

Analyses of typical soils of the cotton States—Continued.

No.	Kind of soil.	Locality.	Depth at which sample was taken.	Soluble silica.	Alumina.	Oxide of iron.	Potash.	Phosphoric acid.	Lime.
	GEORGIA—continued.								
	<i>Long-leaf pine and wire-grass region.</i>		<i>In.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
500	Sandy soil.....	Screven County.....	6	0.87	1.10	0.67	0.32	0.13	0.13
509	Sandy pine woods.....	Telfair County.....	6	1.10	2.26	.97	.09	.04	.02
	<i>Coast region.</i>								
511	Live-oak soil.....	Liberty County.....	6	.30	.62	.29	.06	.07	.11
	LOUISIANA.								
	<i>Alluvial region.</i>								
39	Reddish loam.....	Red River bottom.....	12	4	1.41	1.69	.22	.22	.22
238	Front-lands subsoil.....	Girards.....	10-20	6.69	6.37	4.10	.23	.15	.19
	<i>Attakapas prairie region.</i>								
230	Black prairie soil.....	New Iberia.....	10	9.96	4.83	2.78	.21	.21	1.74
195	Pine prairie soil.....	Serpent Bayou.....	10	2.03	1.71	1.11	.15	.04	.26
	<i>Long-leaf pine region.</i>								
134	Pine-hills subsoil.....	Vernon County.....	8-18	4.39	9.92	3.21	.25	.07	.10
	<i>Oak uplands.</i>								
231	Red-clay soil.....	Vienna.....	10	16.08	11.71	15.93	.27	.31	.12
184	Red upland subsoil.....	Mansfield.....	5-12	6.58	4.99	8.62	.22	.15	.15
232	Yellow sandy soil.....	Bastrop hills.....	12	5.75	4.87	3.55	.44	.10	.10
	MISSISSIPPI.								
	<i>Northeastern prairie region.</i>								
172	Prairie soil.....	Monroe County.....	15	.....	14.22	.....	.33	.10	1.37
125	Black prairie, on which cotton rusts badly.	Buena Vista.....	.....	.....	11.16	5.51	.48	.27	.99
175	Bald prairie.....	Booneville.....	8-10	3.60	14.37	7.65	.86	.16	.99
141	Heavy clay soil.....	Kemper County.....	.....	13.22	16.07	7.09	.43	.19	.54
273	Dark-loam hummock soil.....	Tippah County.....	5	5.96	3.43	3.42	.22	.10	.35
177	Black hummock.....	Lee County.....	3-5	3.80	3.02	1.59	.21	.07	.25
	<i>Flatwoods region.</i>								
230	Heavy clay soil.....	Pontotoc County.....	12	.....	10.30	5.90	.75	.05	.18
147	White-oak flatwoods.....	Chickasaw County.....	6	2.66	1.77	3.06	.13	.11	.08
	<i>Yellow-loam region or oak uplands.</i>								
119	Flatwoods hills.....	Lafayette County.....	6	1.63	1.27	1.63	.15	.04	.14
142	Oak upland soil.....	Greensboro.....	6	2.32	1.87	1.84	.24	.09	.09
246	Red-hill soil.....	Kosciusko.....	12	.....	17.50	10.50	.73	.02	.82
228	Sandy oak uplands.....	Lafayette County.....	5	1.64	2.65	2.53	.12	.15	.15
216	Brown-loam table ds.....	Benton County.....	10	.....	6.28	4.80	.55	.07	.25
156	Big black humme soil.....	Sumner County.....	12	3.64	3.47	2.87	.17	.18	.09
396	Bucksbot soil.....	Coahoma County.....	8	10.90	4.46	2.80	.61	.28	.39
376	Light front-lands soil.....	Indian Bayou.....	5	4.04	2.57	1.85	.23	.16	.15
390	Stiff bucksbot soil.....	Issaquena County.....	12	20.70	10.54	5.82	1.10	.30	1.35
	<i>Cane hills.</i>								
237	Loess.....	Claiborne County.....	.....	.....	2.82	3.27	.51	.14	5.92
117	White hummock soil.....	Bayou Pierre.....	9	2.56	1.39	1	.13	.07	.30
116	Upland loess.....	Claiborne County.....	.....	6.45	2.51	2.95	.36	.14	7.57
	<i>Central prairie region.</i>								
188	Black prairie loam soil.....	Rankin County.....	12	4.46	7.25	4.77	.90	.47	1.04
210	Black prairie soil.....	Smith County.....	.....	.....	10.36	.....	.57	.13	.97
44	Upland prairie soil.....	Clarke County.....	15	16.10	17.83	7.34	.69	.12	2.02
40	Bald prairie soil.....	do.....	8-10	7.83	7.45	4.09	.59	.10	22.57
242	Hog-wallow prairie soil.....	Tallahalla Creek.....	6	.....	10.66	4.12	.53	.06	.42
38	Hog-wallow upland soil.....	Clarke County.....	8	9.71	6.37	3.95	.36	.04	.13

Analyses of typical soils of the cotton States—Continued.

No.	Kind of soil.	Locality.	Depth at which sample was taken.	Soluble silica.	Alumina.	Oxid of iron.	Potash.	Phosphoric acid.	Lime.
MISSISSIPPI—continued.									
<i>Long-leaf pine region.</i>									
			<i>In.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
205	Pale loam soil.....	Simpson County.....	6	2.02	1.48	1.26	0.07	0.07	0.06
202	Red loam subsoil.....	Lawrence County.....	8-18	6.69	5.11	3.65	.27	.10	.06
361	White hummock soil.....	Bayou Pierre.....			6.30	2.70	.25	.10	.12
181	Hummock soil.....	Pearl River.....	6	1.74	.82	.61	.11	.01	.06
214	Sandy soil.....	Jackson County.....	12		.85	.46	.06	.02	.02
88	Sandy sea Island cotton soil.....	Hancock County.....	12	2.45	.46	.52	.05	.10	.10
90	Sandy Sea Island cotton subsoil.....	.....do.....	12-20		.32	.52	.08	.11	.12
NORTH CAROLINA.									
<i>Seaboard region.</i>									
21	Dark mucky soil.....	Mattamuskeet Lake.....		.03	6.40		.16	.30	.12
25	Cypress and green swamp.	White-oak swamp.....		3.60	3.33	.30	.05	.06	.10
<i>Long-leaf pine region.</i>									
13	Gray sandy soil.....	Penny Hill.....	11	4.02	7.40	4.79	.20	.14	.18
17	Gray sandy loam.....	Weldon.....		1.58	2.90	1.58	.14	.12	.12
37	Light-gray soil.....	Selma.....	12	3.67	1.48	.70	.13	.02	.45
11	.....do.....	Sparta.....	3	2.95	1.56	.75	.09	.06	.05
<i>Oak uplands.</i>									
2	Yellow subsoil.....	Raleigh.....	5-20	4.72	3.80	2.82	.12	.05	.07
SOUTH CAROLINA.									
<i>The coast region.</i>									
6	Sandy soil.....	James Island.....	12	2.06	2.85	.60	.13	.21	.04
<i>The upper pine belt.</i>									
8	Sandy soil.....	Savannah River.....	12	1.48	1.85	.74	.08	.04	.11
<i>Red-hills formation.</i>									
1	Virgin red land.....	Orangeburg County....	12	3.06	3.98	1.25	.12	.10	.06
2	Cultivated red land.....	.....do.....		2.85	3.67	1.56	.14	.09	.08
<i>Metamorphic region.</i>									
11	Red clay.....	Spartanburg.....	5-20	5.87	26.54	11.70	.21	.13	.03
TENNESSEE.									
<i>Upland of west Tennessee.</i>									
16	Upland soil.....	Gills Station.....		a86.98	5.03	3.66	.40	.06	.24
17	Loess.....	Memphis.....	12	a76.50	3.10	4.69	.43	.32	3.97
235	Table-land soil.....	Lamar.....	10-20		7.73	3.86	.70	.24	.14
<i>Central basin.</i>									
2	Red clay.....	Florence.....	7-15	a77.79	10.30	6.84	.51	.31	.12
8	.....do.....	Murfreesboro.....	7-15	a82.48	7.77	4.77	.25	.06	.14
12	Poplar land soil.....	Maury County.....	11-23	a81.87	7.12	5.29	.33	.34	.55
14	.....do.....	Hermitage.....	10-22	a84.03	6.98	3.69	.58	.32	.47
10	Mulatto clay.....	Bell Meade (Nashville)	8-20	a58.96	17.30	9.58	.75	.36	8.38
TEXAS.									
<i>Timbered uplands.</i>									
1	Sandy soil.....	Texarkana.....	12	.98	.28	1.03	.05	.09	.27
3	Sandy upland soil.....	Mincola.....	24	3.36	.91	.61	.11	.17	.03
4	Dark loamy soil.....	Palestine.....	8	1.01	1.47	1.61	.11	.19	.15

a Insoluble matter and soluble silica.

Analyses of typical soils of the cotton States—Continued.

No.	Kind of soil.	Locality.	Depth at which sample was taken.	Soluble silica.	Alumina.	Oxid of iron.	Potash.	Phosphoric acid.	Lime.
TEXAS—continued.									
<i>Timbered uplands—Cont'd.</i>									
6	Red glauconitic soil.....	Lee County.....	12	<i>In.</i> 3.89	<i>Per</i> cent. 5.30	<i>Per</i> cent. 9.33	<i>Per</i> cent. 0.72	<i>Per</i> cent. 0.10	<i>Per</i> cent. 0.26
7	Sandy prairie soil.....	Tehuacana.....	12	1.42	.91	1.43	.14	.36	.19
9	do.....	Pierce's Junction.....	8	3.61	6.08	2.40	.29	.16	.65
10	Black waxy prairie soil...	Victoria.....	12	22.42	1.25	11.28	.43	.09	1.05
11	Black prairie upland soil..	Chapel Hill.....	12	12.18	4.16	2.27	.24	.11	.95
34	Dark sandy prairie soil...	Corsicana.....	10	5.18	2.39	1.64	.12	.23	.32
<i>Central black prairie region.</i>									
12	Black sandy prairie soil...	Ennis.....	10	3.69	4	1.77	.29	.05	.59
14	Black waxy prairie soil...	Cleburne.....	12	5.56	5.75	5.35	.37	.18	9.78
15	Black waxy soil.....	McKinney.....	12	17.24	11.07	4.22	.62	.15	7.48
<i>Northwestern red-loam re- gion.</i>									
16	Red-loam soil.....	Jacksboro.....	10	8.65	5.08	5.05	.43	.10	.13
<i>Alluvial or river lands.</i>									
40	Dark-loam second-bottom soil.	Red River.....	12	9.10	3.25	3.30	.40	.16	.47
19	Brazos Valley soil.....	Granbury.....	12	2.15	2.51	2.08	.30	.09	.41
23	Colorado Valley soil.....	Austin.....	10	10.36	3.29	2.93	.58	.21	7.79

THE MANURING OF COTTON.

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HISTORICAL.

In the early history of cotton culture in the United States the great bulk of the crop was made with practically no artificial manuring. The natural fertility of the soil was depended upon to furnish the plant food needed by the crop. Such attempts as were made to increase the natural productiveness of the soil were mainly in the direction of improved mechanical tillage. Even such attempts were, however, limited in scope and imperfect in character. The large area of virgin land in the cotton-growing States, its cheapness, and the peculiar character of the labor employed in cotton culture made it apparently (and probably actually) more profitable to cultivate a given area for a few years only and, when it was "worn out," to abandon it and bring fresh lands into cultivation. The cheapness of slave labor, the peculiar adaptability of the negro slave to the climatic conditions of most of the cotton-growing States, and the necessity of providing employment for the rapidly increasing numbers of slaves—furnishing a labor which, while muscular, was relatively unintelligent—conspired to maintain a system of culture in which the necessity for providing by judicious fertilization against the depletion by continuous culture of a given body of land was not recognized, or, if recognized, the process was deemed impracticable or relatively unprofitable. The small demand made by cotton as compared with other crops upon the plant food of the soil was, moreover, well known as the result of experience, and the best lands of Southern plantations—those which were naturally most fertile—were as a rule reserved for corn, wheat, and other supply crops so far as was necessary, and the residue given over to cotton culture. For the same reason and because, moreover, of the clean culture necessary for cotton with which excessive growth of grass and weeds would interfere, such home manures, as stable manure, etc., as were saved upon the plantations were, when used at all, devoted to the corn and grain lands and practically none applied to cotton. The quantity of such manures made was in any event small, as the stock and cattle upon cotton plantations were as a rule limited in numbers to the bare needs of the plantations, and the mildness of the climate rendered unnecessary such careful housing of farm animals as would conduce to

the saving of manure. Cotton seed was produced in large quantities as a necessary by-product of the cotton crop, and, at the time, the surplus not needed for seeding had no value except for manurial purposes in the crude form.

An examination of the agricultural journals published in the cotton-growing States previous to, say, 1845, shows that the manurial value of stable manure, cotton seed, and similar materials was quite as well known to the cotton planter as to farmers elsewhere at the time.

Under the system of extensive culture found profitable with an abundance of cheap, fresh lands and rapidly increasing possession of slave labor, the economic question presented to the cotton planter was the cost of transporting bulky materials of comparatively small manurial value versus that of clearing new lands as an avenue of employment for his labor. The question was neither ignored nor untested. Numerous instances are recorded of experiments upon the subject by leading, intelligent planters. Experience determined the policy in favor of fresh lands, and stable manure and cotton seed came to be regarded as not worth the cost of handling as fertilizers for the cotton crop. They were used to considerable extent upon gardens and under grain crops, but only in rare instances with cotton. Especially was this true of cotton seed, which, in addition to its superiority in manurial value over stable manure, was collected in large quantities at the gin houses, and, thus accumulated, was more cheaply handled. Various methods were used in applying cotton seed as a manure. Upon small areas the green seeds were sometimes scattered broadcast and plowed under. More frequently they were applied in drills or furrows, in varying quantities and at different depths. It was generally considered judicious to kill the seed before using for manure, to prevent aftersprouting and to secure material in better mechanical condition for handling. This was accomplished in various ways. A common practice was to pile the seeds in large heaps and allow them to stand for several months exposed more or less to the weather. The heat of partial germination would kill the seed and the mass would undergo a process of rotting. The heap was cut down in the spring and the rotted material applied to the land. There was, of course, great manurial waste in this process. Frequently, on cutting down such heaps, the odor of escaping ammonia was so strongly developed as to be noticeable at considerable distances from the heap.

While the cotton crop of itself received practically no artificial fertilization at all, the lands designed for grain and supply crops were manured and otherwise treated in much the same manner as obtained for similar crops elsewhere, so far as the prevailing conditions permitted. The manurial value of soiling crops (especially clover and peas), of fallowing, and of rotation was well understood, and such methods of soil improvement were in many instances practiced. As population increased and fresh lands became less abundant, higher in

price, and more difficult to acquire, cotton, to some extent, was given a place in the rotation of crops, and thus benefited by the fertilization applied to previous crops. In the main, however, the great bulk of the cotton crop previous to 1860 may be said to have been grown without artificial fertilization and mainly upon virgin soils.

As a matter of fact, previous to the civil war, the best lands of the plantations were devoted to food crops, and they were manured and tilled as judiciously as the conditions permitted and the then state of knowledge of scientific agriculture indicated. The profit in the slave depended upon the finding of a market for his labor, and the best market afforded was an extension of the area of cultivatable lands devoted, in their fresh state, to the production of a crop readily convertible into money, peculiarly suited (as the slave himself) to the climate, and in the cultivation of which muscular labor should count for much and intelligence and science for but little. Under the circumstances, there was no profit discernible in the artificial fertilization of a cotton plantation or even in attempted preservation of its original fertility, and as the cotton planter naturally planted for present gain, with but small consideration for the prosperity of posterity, the cotton crop of the United States previous to 1860 was, in the main, made by skimming the virgin soil of the cotton States, the production depending upon the natural fertility of the land.

In 1845 Peruvian guano was first introduced into the United States. In 1846 Mr. David Dickson, of Hancock County, Ga., "saw an advertisement in the American Farmer, Baltimore, of the wonderful effects of Peruvian guano. [He] procured three sacks and used it, and finding it paid used it in increasing quantities till 1855 or 1856, and then went into it fully." This was probably the first instance of the use of a concentrated fertilizer in the cotton-growing States upon crops of any kind, and certainly the first instance of such use with cotton. Mr. Dickson's first experiments with Peruvian guano were upon a small and judicious scale. He applied it to cotton only upon his best cotton lands in comparatively small quantities, and always in the drill. When he "went into it fully" the amount he used was rarely as much as 200 pounds per acre. The successful experience of Mr. Dickson and other prominent planters, who speedily followed his example, led to very numerous experiments with Peruvian guano as a fertilizer for cotton. The history of this famous stimulant manure as a cotton fertilizer in the Southern States was similar to that which it had experienced in connection with other crops elsewhere. For a year or two the results of its use were not only satisfactory but surprising. Subsequently the rapid and excessive growth of weeds, with all the attendant dangers in a region subject to severe drought, was not attended with a corresponding yield of fruit, and the reputation of the guano suffered accordingly. It was suggested that the active stimulant effect of the manure might be overcome by burying the guano deep in the soil, and for a

while this plan was followed quite extensively. It was not found satisfactory, however, and many entirely abandoned the use of Peruvian guano as unprofitable. The dangers attending the use of Peruvian guano as a fertilizer when applied alone were, perhaps, more speedily and more strikingly manifested in the case of cotton than of most other crops with which it was used, because of the initial poverty of the generality of cotton lands, their deficiency in organic matter, the clean culture of the crop, and the heat and droughts of the region in which it was cultivated.

In 1860 came the civil war and almost simultaneously the introduction into commerce on a large scale of chemical manures, as a result of the investigations and teachings of Liebig, the discovery of phosphate deposits, and the opening of the German potash-salts beds. The results of the war, the abolition of slavery, and the introduction of chemical manures completely revolutionized the methods of cotton culture in the Southern States. Up to that date the principal capital of the cotton planter had been the controllable labor of his numerous slaves, the field of its employment—cheap virgin lands—requiring scarcely any other capital for their profitable cultivation. Now his chief and almost sole possession was an extensive domain of worn-out and abandoned land, robbed of its original fertility by the butchery of previous cultivation and offering scant promise of productiveness at the hands of the recently emancipated, unskilled, and irresponsible freedman. Under these circumstances the chemical manure, furnishing plant food in a concentrated form at comparatively small cost, easy of application, guaranteeing a fairly good crop from even the poorest and most exhausted soil with a minimum expenditure of labor in cultivation, and requiring no special skill in its manipulation, was hailed as an agent admirably and peculiarly suited to the necessities and the new conditions of the cotton planter. The obligation no longer rested upon the planter to devote his chief attention and his best lands to the production of food crops for his labor. Cotton was a crop for which there was great demand at good prices and immediate cash payments. An enormous impetus was, in consequence, given to cotton culture in the former slave States. Concentrated manures made such culture possible and profitable, and almost immediately came into well-nigh universal use. Since the close of the civil war to the present time practically all the cotton cultivated in the United States, with the exception of comparatively small quantities grown upon the alluvial soils of great river bottoms and occasional areas of newly cleared land, has been fertilized with concentrated manures. Probably upon no other crop to which they have been applied have these manures exercised so great an influence as upon cotton. Not only were profitable crops made with them upon lands which without them it would not have paid to cultivate, and an immense area of worn-out land thus redeemed to culture, but the stimulant effect of the manure so shortened the period of growth and

maturity of the plant that the climatic limit of culture was extended. Cotton soon came to be grown abundantly over large regions where, previous to the introduction of such manures, killing frosts intervened before the maturity and fruitage of the plant. The enormous increase in the cotton production of the United States since 1860 is undoubtedly to be credited chiefly, if not exclusively, to the use of concentrated manures. Considering the condition of the land and the labor system of the cotton States at the close of the civil war, it is difficult to conceive how cotton culture could have been continued or sustained but for the use of such manures.

Undoubtedly all these circumstances and considerations conspired to invest the commercial fertilizer in the estimation of the cotton planter with something of the character of a fetich, and this led, in turn, to two natural errors on his part—(1) to attach but little importance to difference in chemical composition, quality or character of the various compounds offered in the markets, and (2) to rely too exclusively upon the fertilizer for the production of his crop. During the years of the war, from 1860 to 1865, when the Southern farmer was cut off from communication with the rest of the world, immense progress had been made elsewhere in the study and correct understanding of the value of chemical manures, and research and experiment had indicated approximately the proper qualitative and quantitative composition of such manures for general crops. The trade was not slow to offer these in so promising a market as the cotton-growing States. "Guanos" (some genuine and some so-called), "fertilizers," "complete manures," and innumerable compounds under suggestive appellations which testified to the vigorous and picturesque imagination of the American tradesman were ready in waiting at the restoration of peace and were soon poured in a rapidly swelling flood upon the cotton plantations of the South. "Guano" soon came to be (and still is) the popular designation for all such manipulated goods. The greater number of these were quite similar in character, being mixtures of dissolved phosphate, potash salts, and nitrogenous matters (generally organic). They differed quite widely in quality, however, ranging, in soluble phosphoric acid, from 6 to 10 per cent; in soluble actual potash, from 1 to 4 per cent, and in nitrogen from 1 to 3 per cent, as well as differing in the sources of the materials of which they were composed. A small quantity of the soluble phosphate was obtained from bones; much the larger quantity from phosphate rock. The potash salts were mainly the German kainit and muriate of potash. The nitrogen compounds used were very numerous; mineral salts (sulphate of ammonia and nitrate of soda) and animal matters (dried blood, fish scrap, tankage, etc.) all participated in the construction of these so-called "complete manures." Peruvian and other true guanos were offered in moderate quantities, both in original condition and, profiting by experience, manipulated (with dissolved phosphate to "Phospho-Peruvian," for

instance) to safer composition for general use. For a number of years the choice of a "guano" was determined mainly by the persuasive representations of the seller of the goods or the personal experience of the buyer or his friends in their actual use, and the relative prices of different goods were fixed more by the reputation thus gained for the "brand" than by their relative contents of actual plant food. Indeed, even when competition and the agreement of manufacturers and dealers brought all such manipulated goods to an approximately uniform price the variation in quality, as indicated by chemical analysis, was still quite great among them and yet was practically disregarded by the purchaser as a rule. "Guano" was "guano," and aside from a slight prejudice (irrational, no doubt, but comprehensible) in favor of the dark-colored and bad-smelling varieties no great importance was attached to its composition or its variations, provided it made cotton—which even the poorest in quality of those offered was quite competent to do. To adopt an oft-used expression, the use of "guano" in cotton culture was the result of "revolution," not of "evolution," and it is small wonder, therefore, that it was neither strictly scientific nor thoroughly efficient. To the cotton planter after the war, with sterile lands and his labor system wrecked, "guano" was offered as the one, sole chance for profitable tillage of his soil. It came to him apparently full-fledged and perfected. He adopted it in his dire extremity. It served him admirably and speedily assured a certain measure of prosperity. It is not surprising that he should have been slow to inquire into the rationale of its value or indisposed to meddle with its composition. Anything like scientific experimentation with chemical manures on a large scale in cotton culture was therefore not undertaken and was very difficult to secure. The use of such manures was largely empirical and necessarily in many cases more or less injudicious.

The ease with which cotton could be produced by the use of such manures led, as has been said, to an undue dependence upon them for the making of the crop. Proper mechanical tillage was neglected, and the previously worn-out lands were again merely skimmed—this time with the addition of the fertilizer. As a consequence it was not long before the great bulk of the cotton lands began to show the effects of a continuous, clean, superficial culture in a region subject to torrential, washing rains in winter and hot, baking suns in summer. Moreover, for reasons above mentioned, cotton raising had become the absorbing agricultural occupation of the country. The production of grain and other crops, of live stock and domestic animals was neglected, and even the necessary food supplies for the family and the labor were purchased of the merchant by the very large majority of Southern farmers. Payment for these supplies, including the guano that was used, was made, as a rule, after the crop was gathered, and thus began the unfortunate

credit system, which, by reason of its enormous interest charges in the form of "time prices," soon involved the cotton growers not only in a stupendous burden of debt, but also in a fixed and ruinous system of agriculture from which there seemed no escape. Cotton was the basis of credit; no other farm product was acceptable in payment of debts; upon the agreement to produce it credit (at fearful interest charges) could alone be had. For the farmer without capital it was cotton or starvation; whether he would or no, he was forced to raise cotton; to raise cotton required guano; to obtain guano a debt was incurred payable only in cotton. It is evident that this "all-cotton" system of agricultural operations afforded but little opportunity for the making and use of farm manures, the growing of soiling crops, rotation, and the other aids to culture possible in diversified farming. In the course of time the ill-treated soils failed to respond as liberally as at first to the application of the concentrated fertilizer; the rapidly falling price of cotton, consequent upon the enormous production, decreased the purchasing ability of the individual farmer, and a revulsion in public sentiment on the subject of fertilizers ensued in which "guano"—the chief, the necessary agent in the making of cotton—fell from the high estate in which it had been held as the cotton planter's best friend and came to be regarded as the cause of all his woes. In the newspapers, in public assemblies, in meetings of granges, alliances, and similar organizations denunciations of commercial fertilizers were frequent and vehement and resolutions galore were unanimously and enthusiastically adopted recommending and pledging a restriction of their use. Even legislation was invoked to purge the body politic of the suspected source of current ills, and in the legislatures of a number of the cotton States measures were introduced (although none, so far as can be ascertained, were actually enacted) designed to hamper or suppress the guano trade or to make the legal test of the genuineness of a commercial fertilizer the actual profit derived from its use.

What declamation, resolutions, and legislation were powerless to achieve, however, necessity slowly accomplished, a recasting of the plan of farming operations upon the cotton farms. By degrees the acreage of cotton was relatively decreased. Food supplies, stock, and cattle were raised. The cotton planter endeavored to "live at home" and make the cotton his "surplus crop." Cotton, in many instances, was entirely abandoned and replaced by fruit, truck, and other crops. With the diversification of crops came better tillage, renovating crops, home manures, and a better understanding and more judicious use of concentrated fertilizers. To this improved condition the major part of the cotton States have attained at the present time.¹

In the meanwhile numerous agencies had been at work in the cotton States looking to the study of the scientific culture of cotton and a

¹ See also article on culture of cotton, p. 225.

dissemination of a knowledge of the principles of agricultural chemistry which at this period exerted so potent an influence in all the processes of agriculture and particularly in the methods of manuring crops. Not a few of the leading and most intelligent cotton planters speedily informed themselves of the progress the world had made during the war-time isolation of the cotton States and began to make intelligent application of this knowledge to their own conditions. Numerous agricultural journals were established and devoted large portions of their space to the discussion of the subject of the fertilization of cotton and especially of the use of chemical manures. Land-grant colleges, provided for by the act of Congress of 1862, were now established in the cotton States, which, during the war, had been excluded from the benefits of the Federal legislation, and did much to popularize a knowledge of the natural sciences pertaining to agriculture and to enlighten the people on the subject of commercial fertilizers and the nature and proper mode of use of chemical manures. Experiments of a more or less tentative character were carried on at some of the colleges; plant and other analyses were made and published; and the beginning was thus made in the study of the scientific fertilization of cotton. Finally, when, in 1888, agricultural experiment stations were generally established in connection with the colleges, a number of these—notably those of Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee—entered upon careful and systematic study of the subject.

Following the plan previously adopted in some of the Northern States, legislation was enacted in most of the cotton States providing for the “official control” of the sale of commercial fertilizers, committed variously to departments, bureaus, or boards of agriculture, and, in some instances, to the colleges of agriculture. These laws—in most cases prescribing minimum contents of valuable chemical ingredients in the fertilizer admissible to sale—were intended only to guarantee the genuineness of the manure and to guard the purchaser against imposition in the composition of the goods. They were educative, however, in that they made familiar the chemical terms “available phosphoric acid,” “potash,” “nitrogen,” “ammonia,” etc., and thus aided the popular apprehension of the functions of the manure.

As early as 1858 Mr. Dickson (hereinbefore referred to) “treated bones with acid, according,” as he says, “to the practice of English farmers,” and used the compound, either alone or mixed with Peruvian guano, under cotton. Later he used commercial “dissolved bone,” and experimented largely with it and other commercial manures. In 1869 he published a little book, *Dickson’s System of Farming*, consisting largely of a collection of his contributions to current agricultural journals, which had at the time a wide circulation and excited considerable interest. In it he strongly recommends good tillage, renovating crops, and rotation, and does not underestimate the value of “home

manures," but attaches prime importance to the use of chemical manures as fertilizers for cotton, on which subject he says:

After twenty years of diligent research and study of the laws of nature as applied to agriculture, with the experimental use of Peruvian guano and other guanos upon soils and crops, I have determined upon the following combination of commercial manures as the best and most valuable for all crops:

Formula, "Dickson's compound."

	Pounds.
Peruvian guano.....	100
Dissolved bones.....	100
Common salt.....	100
Land plaster.....	50
Well mixed.	

This compound I have now been using for many years upon all my farm crops, and unfailingly with satisfactory results. In my hands, and under my system of farming, this compound has never failed to grow me good crops and bring me satisfactory dividends. It has always paid me, and my clear profits have always been larger in proportion to the amount of the compound applied—up to 1,000 pounds per acre. I have long since learned not to fear failure of making paying crops, no matter the season.

Subsequently Mr. Dickson modified this formula somewhat for cotton, as follows:

	Pounds per acre.
Dissolved bones.....	250
Peruvian guano.....	165
Land plaster.....	100

This formula was based, of course, upon no accurate study of the cotton plant and its requirements, but was merely such a fairly well-proportioned mixture of concentrated manures as experience had shown to be profitable. Other writers were inclined to dispute the importance he attached to Peruvian guano, suggesting other combinations of the commercial fertilizers available, and the battles of the "humus," "mineral," and other theories of fertilization were fought over in the agricultural journals without much, if any, careful and genuine experimentation. Nevertheless, "Dickson's compound" and similar mixtures were used to a considerable extent, and no doubt with profit.

For a few years subsequently to 1877 "composts" attained considerable celebrity as fertilizers for cotton, chiefly through the practice and writings of Mr. Farish Furman, of Baldwin County, Ga. Recognizing the nitrogenous content of cotton seed and stable manure, it was recommended to compost these with acid phosphate and potash salts and thus cheapen the cost of the "complete fertilizer" as compared with that of the "ammoniated" guanos sold by the manufacturers. The original formula for a compost recommended by Mr. Furman was as follows:

Furman's formula.

	Pounds.
Barnyard manure.....	750
Cotton seed.....	750
Acid phosphate.....	367
Kainit.....	133

2,000

To be used at the rate of from 400 to 800 pounds per acre.

These exact proportions were not always followed by those who adopted Mr. Furman's general suggestion.

The general plan of making a compost was to put down on an earthen floor a layer (usually of about 20 bushels) of stable manure, then a layer (20 bushels) of cotton seed, then a sack (200 pounds) of acid phosphate, with occasional addition of kainit or muriate of potash; then repetition of the layers to any extent desired, covering the whole frequently with a layer of absorbent earth. The compost heap was protected roughly from the weather, frequently in a latticed pen, and kept moderately moist. It was put up in the autumn immediately after the close of the ginning season and allowed to stand until spring. It was then cut down, mixed, and applied in the drill. It was assumed that the partial rotting of the compost in the heap would improve its quality as a manure. Subsequently it was doubted whether this improvement was sufficient to compensate for the trouble and cost of making the heap, and the green cotton seed, stable manure, and acid phosphate were composted (i. e., simply mixed together) in the drill at the time of applying the fertilizer, immediately or a short while before planting. Composting, both in the heap and in the drill, is still practiced to a considerable extent, although probably not so largely, relatively, as when first introduced, and large quantities of stable manure and cotton seed especially are thus used in the fertilization of cotton.

Between 1870 and 1880 a large number of cotton-seed oil mills were erected in the cotton States. These threw upon the market, at comparatively low prices, a large quantity of cotton-seed meal, for which the stock and cattle of the country did not furnish a sufficient market for complete utilization as a feeding stuff. Numerous experiments demonstrated the suitability of cotton-seed meal as an "ammoniator" in fertilizers for cotton, and it was used in increasing quantities by the manufacturers of ammoniated fertilizers. At the present time it is probably the most largely used source of nitrogen in the commercial and other concentrated manures applied to cotton.

As popular understanding of the composition and functions of chemical manures increased, greater variety and discrimination were observed in the purchase of commercial fertilizers. The cotton planter was fortunate in having immediately at hand the main constituents of manipulated manures. Acid phosphate was made in large quantities at Charleston, from the South Carolina phosphate rock, and subsequently at numerous other points in the Southern States, from both South Carolina and Florida rock. Cotton-seed meal was produced at the numerous oil mills in the South. German potash salts were imported direct into Southern ports, and a limited supply of ashes rich in potash (15 to 25 per cent) was furnished by the oil mills which used cotton-seed hulls largely for fuel. Many cotton planters began to purchase these raw materials of chemical manures and use them, either separately, or, more generally, mixed in such proportions as experience (or

perhaps, more truly, reference to the average analyses of the commercial ammoniated fertilizers) seemed to indicate as best suited to the requirements of the cotton crop. Numerous "formulae" were used, none of them professing to be based upon accurate information furnished by strictly scientific experimentation, but providing the approximate proportions of available phosphoric acid, potash, and nitrogen which research and experiment elsewhere had shown to be adapted to crops in general. The following is a typical example of the mixtures used:

	Pounds.
Acid phosphate	1,200
Cotton-seed meal	600
Kainit	200
	<hr/> 2,000

If muriate of potash or cotton-hull ashes were used in place of kainit, the amount was usually smaller and the proportion of acid phosphate correspondingly increased.

As the raw materials varied somewhat in quality these mixtures also varied in analysis, ranging, in general, from 7 to 10 per cent of available phosphoric acid, 2 to 4 of nitrogen, and 1 to 3 of potash. Such mixtures appeared to give generally satisfactory results with cotton, and were and still are used quite extensively in all the Southern States. The cotton-oil mills as a rule were willing to exchange cotton-seed meal for cotton seed, generally at the rate, approximately, of 1 pound of meal for 2 pounds of seed, and the mixing of chemical manures on the farm was thus encouraged.

Subsequently to 1885 the relative quantities of acid phosphate (with or without a small content of potash) purchased by the cotton growers, as compared with the amounts of ammoniated guanos, largely increased, indicating an effort to supply the crop with its nitrogenous nutriment by use of soiling crops, stable manure, green and rotted cotton seed, and other home manures.

SCIENTIFIC EXPERIMENTS BEARING UPON THE MANURING OF COTTON.

With the establishment of agricultural experiment stations in 1888 systematic experimentation in the fertilization of cotton began, mainly at or under the auspices of the stations in the cotton States. These experiments have been diverse in character, varied in conditions, and unequal in the attention, care, and length of time devoted to them. They have added much of great value to our accurate knowledge on the subject, and have indicated certain conclusions which may be provisionally accepted with some degree of confidence. Upon many points, however, they have not yet afforded positive and definite conclusions. The apparent results of the experiments are in many cases contradictory and in many more inconclusive. This is not to be considered surprising, inasmuch as the experiments, without exception, have been field experiments, subject to all the contingencies, inconsistencies, and

misleading results incident to work of this description. No pot or water culture of cotton seems to have been undertaken; at any rate no results of such experiments have been published.

Research and experiments at the stations bearing upon cotton culture have covered a wide range of investigation.

Of these experiments nothing need here be said further than to note, as bearing upon the subject of the fertilization of cotton, certain results of the chemical analysis of the plant, as follows:¹

Fertilizing constituents contained in a crop of cotton yielding 300 pounds of lint per acre.

Constituent.	Amount per acre.						
	In 300 pounds lint.	In 654 pounds seed.	In 404 pounds bolls.	In 575 pounds leaves.	In 658 pounds stems.	In 250 pounds roots.	In 2,841 pounds total crop.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Nitrogen	0.72	20.08	4.50	13.85	5.17	1.62	45.94
Phosphoric acid .....	.18	6.66	1.14	2.57	1.22	.38	12.15
Potassium oxid	2.22	7.63	12.20	6.57	7.74	2.75	39.11

[The average production of cotton per acre is much less than 300 pounds of lint—probably something less than 200 pounds. A calculation accordingly can, however, easily be made from the figures given above.]

The station experiments bearing directly upon the fertilization of cotton may be roughly classified, by the end in view, as follows:

(1) To test the yield and profit from the use of fertilizers as compared with unfertilized soil.

(2) To test the comparative values of commercial fertilizers and home manures.

(3) To determine the kind of fertilizer (chemical manure) best suited to cotton.

(4) To determine the amount of fertilizer giving best results.

(5) To determine the best mode of application of the fertilizer.

(6) To determine the best time of application.

(7) Miscellaneous.

Omitting mention of such experiments as were manifestly unreliable by reason of accident, omissions, lack of care and attention, or from other causes, a succinct review of the results obtained in these several lines of experimentation is here presented.

YIELD AND PROFIT FROM THE USE OF FERTILIZERS ON COTTON AS COMPARED WITH YIELD AND PROFIT FROM UNFERTILIZED SOIL.

The results of experiments instituted on this line vary greatly with the nature of the soil, the seasons, the culture, and the kinds and amounts of manures employed. With the exception of those upon one class of soils, however, they all agree in demonstrating that large profit attends the judicious manuring of cotton. The exception is in the case of the "black prairie" or "canebrake" soils of the alluvial formations of the Gulf States. Experiments upon such soils at the

¹ Tennessee Sta. Bul., Vol. IV, No. 5.

Alabama¹ stations indicate that no compensating returns may be expected from the use of manures "except crushed cotton seed and cotton-seed meal, and even with these the returns are small." Drainage and good mechanical tillage seem to be the chief need of these soils. Upon other soils of Alabama, however, "the percentage of profit from a judicious use of fertilizers, followed by intelligent cultivation, is most satisfactory." Upon a poor sandy soil, with no retentive clay within 3 feet of the surface, "even with unusual expense for fertilizers, the increase resulting from the use of commercial manures paid 85 per cent profit on cost."

Experiments made under direction of the Arkansas Station indicate that "fertilizers are generally remunerative," the percentage of profit ranging from 20 to 180. Five hundred pounds per acre of rotted cotton seed gave a net profit of \$3.93. Five hundred pounds each of cotton seed (at \$6.50 per ton) and cotton-seed meal (at \$20 per ton) gave equal financial profit.

At the Georgia Station the use of commercial fertilizers was almost always profitable, the percentage of profit ranging from 5 to 250.

The stations of Louisiana, Mississippi, North Carolina, and South Carolina obtain similar results from experiments, and indicate that "the application of fertilizing material to cotton seems, with few exceptions, to be profitable."

W. B. Dana² states that in 1878 "the increased productiveness due to the use of commercial fertilizers is estimated to be 50 per cent. The effect does not all pass off the first season, but in about the proportion of 70 per cent the first year, 20 per cent the second year, and 10 per cent the third year."³

To the teaching of these specific experiments may be added the general experience of the great bulk of the cotton planters, and it may be accepted as proven that cotton responds favorably to artificial manuring, and that upon most of the soils of the cotton States all kinds of manures, including concentrated commercial fertilizers at the prices at which they are commonly held, are profitable when judiciously used.

COMPARATIVE VALUES OF COMMERCIAL FERTILIZERS AND HOME MANURES.

Results of experiments on this point also vary considerably with the soil and season.

In Alabama, green manuring appears to have been most profitable upon both prairie and sandy soils. Peas and melilotus both gave good results; pea vines appeared to be the best fertilizer for cotton; peas were more economical for green manuring for one season,

¹For convenience, reference is omitted to the specific title and page of authorities consulted in the preparation of this article. A short bibliography of the subject is given at the end of the article which embraces all the authorities to which reference is made or from which quotations are taken.

²Cotton from Seed to Loom.

³Hammond estimates that in 1889 627,899 tons of fertilizers were used on cotton in the United States, and that the use of this amount of fertilizer resulted in an increased crop of 728,337 bales of seed cotton, or a little over 9 per cent of the crop of that year.

melilotus for two; stable manure generally gave good results, lasting in effects; upon canebrake soils, both drained and undrained, crushed cotton seed and stable manure each gave small returns, commercial fertilizers none. Upon a field with sandy soil which had not been cultivated for many years stable manure, contrasted with chemical manures of various kinds and in various proportions, produced the largest increase and the largest profit per acre, but it was noted that the amount applied was at the rate of nearly 2 tons per acre, or one-half ton more than the amount annually saved from each mule kept. "There is no question about the efficacy of good stable manure properly used, but the available supply is too small."

In Arkansas, cotton seed and cotton-seed meal gave best results when tested against acid phosphate and kainit separately. On worn sandy bottom lands almost continuously planted in cotton for thirty years cotton-seed meal and stable manure each gave better results than chemical manures, and better results when used alone than when mixed with acid phosphate and kainit. "There is no better fertilizer for cotton than stable and barnyard manure." Other experiments indicated, however, that stable manure (from feeding cotton seed and pea-vine hay) extended the growing season of the plant, delayed maturity of the crop, and hence decreased the possible yield and profit.

In Georgia, cotton seed and stable manure alone were found unprofitable as compared with the same composted with acid phosphate, and gave less profit, when used in amounts of equal cost, than chemical manures.

In Louisiana, cotton seed and stable manure alone were of doubtful profit as compared with chemical manures. "Manure from the farm should be reenforced with cotton-seed meal and composted with acid phosphate. * * * The compost is the best manure in the world for cotton." The formula recommended for the compost is—

Green cotton seed.....	bushels..	100
Stable manure.....	do....	100
Acid phosphate.....	pounds..	2,000

Almost as effective as the compost was a homemade chemical manure, constructed as follows:

	Pounds.
Acid phosphate	1,100
Cotton-seed meal.....	700
Kainit	200

In Mississippi, commercial fertilizers were more profitable than stable manure or cotton seed alone, but paid best in connection with an abundance of organic matter. Composts variously proportioned gave best results.

In North Carolina, barnyard manure was found to be especially effective, partly on account of its after effects, and somewhat the best of all fertilizers. Its first cost (\$1 per load), however, detracted from the profit, and a combination with acid phosphate was much more profitable.

Home composts gave generally good results, and next to these a home mixture of—

	Pounds per acre.
Acid phosphate	200
Cotton-seed meal	100
Kainit	50

KIND OF FERTILIZER (CHEMICAL MANURE) REQUIRED BY OR BEST SUITED TO COTTON.

Assuming phosphoric acid, potash, and nitrogen in suitable compounds to be the three chemical substances proper and possible to be used in the fertilization of cotton, the experiments have been mainly conducted with a view to determine the relative importance of these, the best form of each (i. e., of the compounds available in commerce), and the proportions of each in a mixed fertilizer most suitable to the requirements of the cotton crop, regard being had to the character of the soil to which they were applied and account being taken of the profit afforded.

In Alabama, in 1888, experiments were made upon a sandy drift soil to determine the proper ratio of nitrogen to phosphoric acid in fertilizers for cotton. The amount of phosphoric acid was constant—200 pounds of English superphosphate (12 per cent soluble) per acre—and the amount of nitrogen (in dried blood and cotton-seed meal) varied so as to furnish 1 part nitrogen to 1, 2, 4, 6, and 8 parts phosphoric acid. The smallest quantity of nitrogen employed gave as good results as larger quantities. No difference was observed in the two sources of nitrogen. In 1889 cooperative experiments under direction of the College Station were made on 9 farms furnishing typical soils of the State. The fertilizers used and the amounts per acre were: For nitrogen, sulphate of ammonia, 80 pounds; nitrate of soda, 100 pounds; cotton-seed meal, 200 pounds; for phosphoric acid, dissolved boneblack, 200 pounds; for potash, kainit, 100 pounds. Green cotton seed (960 pounds per acre) and stable manure (3,000 pounds per acre) alone and in combination with acid phosphate were also used. The fertilizers were applied singly and in various combinations to fifteenth-acre plats without duplication. Some of the experiments proved to be of little value, owing to mistakes and omissions; others indicated with some clearness that phosphoric acid was the ingredient chiefly needed in the soils tested—sandy and brown loam, with clay subsoil. An experiment was also made with cotton on newly cleared land, in which acid phosphate was applied on two plats, acid phosphate and cotton-seed meal on two, and no manure on one. The results indicated that the natural soil did not furnish sufficient nitrogen and was very deficient in phosphoric acid for the requirements of the crop. In 1890 an experiment was made on fifteen plats in a field which had not been cultivated for many years. The fertilizers used were sulphate of ammonia, dissolved boneblack, and kainit, singly, two and two, and all three together. Floats, alone and in combination, separately, with sulphate of ammonia and green cotton seed, was also used, as also stable manure and green cotton seed singly. Contrast was made with plats receiving no manure. The results indicated that this soil needed nitrogen and

potash, but was most deficient in phosphoric acid for the production of the crop. This experiment and another on a sandy drift land long in cultivation indicated that floats, in connection with cotton seed, was more profitable than acid phosphate. In 1891 cooperative experiments were made on 36 farms in various parts of the State with different fertilizers in different amounts and combinations. The experiments were not perfectly accurate, but indicated certain conclusions. Potash did not seem to pay; phosphates applied alone did not have much effect; nitrogenous fertilizers in all forms gave an increased yield. In 1893 certain experiments indicated that nitrogenous fertilizers (cotton-seed meal and nitrate of soda) alone on cotton pay on sandy lands, providing there are good rains following their application.

The general indications afforded by the great number and variety of cooperative experiments made since 1888 under the auspices of the Alabama Station, upon a variety of soils of the State, the majority of which were sandy, are that a complete fertilizer is needed for cotton. Phosphoric acid is often the controlling element, and a sufficiency of nitrogen is frequently lacking in the soil. Potash alone does not pay. Phosphates applied alone have some effect, but much less than when combined with nitrogen. Nitrogen, particularly in organic forms, is profitable, especially in connection with phosphates. The unfertilized soil of the station needs nitrogen, potash, and phosphoric acid. It is especially deficient in the latter. "In new ground the decomposition of the vegetable matter in the soil did not furnish all of the nitrogen needed by the cotton; the increase from phosphates alone was satisfactory, but the increase caused by the addition of nitrogen did not justify its use." As to floats, the experience of several years indicated that a part of the phosphoric acid becomes available to the plant the first season, but the solubility is much facilitated by combining the floats with cotton seed or cotton-seed meal.

In Arkansas, in 1889, experiments were made on sandy bottom land which had been almost continuously planted in cotton, without manuring, for thirty years. Acid phosphate, cotton-seed meal, and kainit were used singly and in combination; also stable manure and composts in different amounts. Nitrogenous manures alone were profitable. Neither acid phosphate nor kainit alone paid. All of the different plats on which cotton-seed meal was used, either singly or in combination, gave some profit, and "this was due not to the acid phosphate or kainit, but to the cotton-seed meal." These results were confirmed by similar experiments made in 1891. Cooperative experiments made in 1888 at five points in the State, and repeated in subsequent years, indicated that a complete chemical fertilizer is needed for cotton. A combination is provisionally recommended of—

	Pounds per acre.
Acid phosphate	200
Cotton-seed meal	200
Muriate of potash.....	50

In Georgia a series of excellently arranged and very carefully conducted experiments have been in progress upon the station farm since 1890. The soil of the station is somewhat irregular in character, but is, for the most part, a gray sandy loam underlaid by yellow clay and, previous to the institution of the experiments, had been in continuous cultivation for a number of years. Fertilizing materials in great variety and in many different combinations were used. The results of the experiments have not been strictly accordant, but the following general conclusions seem to be provisionally warranted. Cotton requires a complete manure, i. e., one containing soluble phosphoric acid, potash, and nitrogen. Neither phosphoric acid nor potash give as good results alone as when combined with each other. Phosphoric acid alone largely surpasses no manure. Potash alone is doubtful; sometimes it affects the yield injuriously. Nitrogen alone has little or no effect, but has very decided effects when mixed with phosphoric acid and potash. In some cases nitrogen seems to be the controlling element in a fertilizer, but, on the whole, phosphoric acid is most effective in increasing the yield. Cotton-seed meal (and cotton seed) and nitrate of soda seem to be the best forms of nitrogen for cotton and are about equal in value, proportionately to the content of nitrogen. There is little or no difference in the value of kainit and muriate of potash. The phosphoric acid in floats and Florida soft phosphate is not in a sufficiently soluble and available condition to answer the needs of the cotton crop. The best proportions of the three elements in a complete fertilizer for cotton are, approximately, nitrogen, 1 part; potash, 1 part; phosphoric acid, $3\frac{1}{2}$ parts. Of such a complete fertilizer the quantity to be used per acre should be an amount furnishing nitrogen, 20 pounds; potash, 20 pounds; phosphoric acid, 70 pounds.

In Louisiana admirably conceived and carefully conducted series of field experiments in the fertilization of cotton have been made both at the State Station, at Baton Rouge, and at the North Louisiana Station, at Calhoun, beginning in 1886 and still in progress. Plats of uniform size were manured with nitrogenous, phosphatic, and potash fertilizers of different kinds and in different proportions, separately and in great variety of combination. The questions tested were:

(1) Do these soils (the worn "sandy lands" and "red lands" of Louisiana) need nitrogen to grow cotton profitably? If so, in what form can it be best presented, and in what quantities per acre?

(2) Do these soils need phosphoric acid? If so, which is the best form, and in what quantities per acre?

(3) Do these soils need potash? If so, which is the best form, and in what quantities per acre?

The results of the experiments were, in some instances, inconclusive, and in some apparently contradictory, as the seasons and the conditions varied. On the whole, however, the following conclusions seem justified as the result of the entire series of experiments:

(1) These soils need nitrogen, and nitrogenous manures may profitably be used in the fertilization of cotton.

(1a) All forms of nitrogenous matters (vegetable, animal, and mineral) are satisfactory and profitable, but, on the whole, they stand in the following order of excellence: (a) vegetable (cotton seed and cotton-seed meal); (b) animal (dried blood, fish scrap etc.); and (c) mineral (sulphate of ammonia and nitrate of soda).

(1b) One ration (24 pounds) of nitrogen per acre is more profitable than larger quantities.

(2) These soils need phosphoric acid. Phosphatic manures may be profitably used in the fertilization of cotton. They are not so necessary (upon these soils), however, as nitrogen.

(2a) The soluble forms of phosphoric acid (in dissolved boneblack and acid phosphate) are emphatically better than the insoluble forms (in floats and similar materials).

(2b) One ration (24 pounds per acre) of phosphoric acid is more profitable than larger quantities.

(3) Potash in no form, either alone or combined with other manures, is needed for these soils. Potash manures are not profitable in the fertilization of cotton.

"It is very certain that phosphoric acid is needed to grow cotton successfully, but in small quantities and combined always with nitrogenous manures."

In Mississippi experiments in the fertilization of cotton were made at the College Station and at Holly Springs in 1888-1893. The results indicate that on upland soils the fertilizer should be rich in organic matter and nitrogen and contain more potash than phosphoric acid. On sandy valley lands the phosphoric acid should predominate. Lime soils require large quantities of potash. On soils poor in lime potash was not needed or did not pay. On black prairie lands the value of concentrated fertilizers was not definitely indicated. The results in different years were conflicting. Cotton-hull ashes were found to be an excellent form of potash.

In North Carolina experiments "on representative soils of the chief geological areas in the State" were conducted in 1890-1894. Stable manure gave best general results in yield, but was not always most profitable on account of initial cost. Next to stable manure, a "complete fertilizer" gave best results, and the proportions per acre recommended are:

	Pounds.
Acid phosphate.....	200
Cotton-seed meal	100
Kainit.....	50

Acid phosphate alone was, for the most part, profitable. Cotton-seed meal alone was profitable in the majority of cases. Kainit alone was unprofitable except in the case of the poor sandy lands of eastern North Carolina.

In South Carolina a very elaborate and most carefully conducted series of experiments was made upon the station farms (two), situated

in different sections of the State, and extending over three years—1888–1890. The soils selected were typical of the “upland” soils of the cotton States, and were “very thin, being greatly exhausted by years of improvident culture.” Applications of fertilizers (phosphatic, nitrogenous, and potash) of various kinds were made, separately and in various combinations, and in different amounts, but more particularly in the approximate quantities and proportions shown by existing analyses of the cotton plant to be necessary for the requirements of the crop. The details of the experiments and the results have been reported in a bulletin of the United States Department of Agriculture.¹ The conclusions reached are in part as follows:

- (1) Cotton requires nitrogen, phosphoric acid, and potash.
- (2) Of the three, phosphoric acid is relatively the most important and controls the action of the other two. It can be used alone with some advantage to the crop, but much more effectively in connection with potash and nitrogen.
- (3) Nitrogen is relatively more important than potash. It can only be advantageously used in combination with phosphoric acid or phosphoric acid and potash.
- (4) Potash, like nitrogen, is of little value to cotton when applied separately; it must be combined with the other constituents.
- (5) Expressed in terms of the latest analyses of the cotton plant, the proportions and amounts of nitrogen, phosphoric acid, and potash required are as follows: Between three-sevenths and four-sevenths nitrogen, about four and one-fourth phosphoric acid, and between one-third and one-half potash. With proper allowance for the cost, as well as the effect of each application, the requirements may be more exactly given as follows: Nitrogen, 0.43; phosphoric acid, 1.16; potash, 0.38. In other words, the required proportions are: Nitrogen, 1; phosphoric acid, $2\frac{1}{4}$; potash, $\frac{3}{4}$; and the amounts called for by a crop yielding 300 pounds of lint per acre are: Nitrogen, 20 pounds; phosphoric acid, 50 pounds; potash, 15 pounds.
- (6) The amount of phosphoric acid determines the amount of nitrogen and potash. With a given amount of the first, only certain amounts of the last two can be profitably used.
- (7) Potash can be as effectively supplied by muriate of potash or kainit as it can by sulphate of potash.
- (8) Phosphoric acid is of value to cotton in proportion to its solubility; hence, the several kinds of phosphatic manures can not be indifferently employed. Preference must be given to acid phosphates containing considerable percentages of soluble phosphoric acid. Insoluble phosphoric acid in slag, floats, or marl is of little direct value to the crop upon which it is applied, and even granting that its effects in the soil may be lasting they are not, in the long run, sufficiently pronounced to meet the interest on the capital invested in the application.

¹Farmers' Bul. 14.

(9) Inorganic, organic, and mixed nitrogen are of very nearly equal value to cotton. The slight difference is in favor of the last two. Stable manure containing organic nitrogen is the best fertilizer of its class, and is lasting or cumulative in its effects. The organic nitrogen of stable manure, to the amount of 50 per cent, can be fully replaced by the inorganic nitrogen of nitrate of soda. As between cotton seed and cotton-seed meal, there is a slight difference in favor of the latter. Whole cotton seed is as efficacious as ground cotton seed. Inorganic nitrogen in nitrate of soda is about as valuable to cotton as organic nitrogen in cotton seed or cotton-seed meal.

The results obtained in Georgia and South Carolina are worthy of special consideration in this connection, as the experiments yielding them were conducted specifically for determination of the points now under discussion.

THE AMOUNT OF FERTILIZER PER ACRE GIVING BEST RESULTS.

The experiments bearing upon this question are somewhat meager and the results uncertain. The amount of fertilizer which may be judiciously and profitably employed is shown clearly to depend upon the character, condition, and previous treatment of the soil, and to some extent upon the season. Very few systematic experiments have been made to test this specific question.

In Alabama one series of experiments indicated that an application of 1,000 pounds per acre of a complete fertilizer was not as profitable as one of 500 pounds, although the yield was somewhat increased.

In Georgia large doses of fertilizer applied at planting or during the earlier periods of growth resulted in earlier maturity of the crop, without, however, sensible increase in profit. The results of experiments conducted for several years on series of plats of gravelly gray soil with yellow subsoil, in which fertilizers were applied at the rates of 400, 600, and 1,200 pounds per acre, indicated—

(1) That, while heavy doses of fertilizers do not give a corresponding increase in the yield of cotton, or so large a percentage of profit, yet such heavy applications, within reasonable limits, are judicious, provided the land is in good condition.

(2) That the limit or maximum amount of fertilizers that can be safely and profitably applied to land in good condition varies considerably, say from 500 to 1,000 pounds per acre, according to seasons, variety of cotton, etc. In these experiments the maximum amount that was immediately profitable was probably between 500 and 700 pounds per acre.

It is concluded that, in general, the most effective amount of fertilizer was 652.6 pounds per acre, compounded as follows:

	Pounds.
Acid phosphate	468
Nitrate of soda	130
Muriate of potash.....	54.6
	<hr/> 652.6

or such an equivalent amount of similar mixtures as will furnish per acre, approximately, phosphoric acid, 70 pounds; nitrogen, 20 pounds; potash, 20 pounds.

It has been shown that \$8 worth of a well-balanced fertilizer may be expected to increase the yield of seed cotton on 1 acre 1,000 pounds. But such results can only be attained by concentrating the fertilizer on the best land, not by scattering it at the rate of 100 or 200 pounds to the acre over a large, worn-out plantation. The mistake should not be made of applying large amounts of concentrated fertilizers on thin, worn-out land. The larger the application the more important is it that the land be in the best possible condition.

In North Carolina heavy applications of stable manure, while somewhat proportionately increasing the yield, were not profitable.

In South Carolina it is concluded that "the amount of phosphoric acid and proportionate amounts of nitrogen and potash can not be indefinitely increased with the expectation of obtaining a corresponding increase in the crop. The gain in crop does not keep pace with increase of fertilizers, and a point is speedily reached beyond which this gain is not sufficient to meet the additional cost of the heavier applications. The soil can not be profitably forced; the application of fertilizers must be regulated by its mechanical as well as chemical condition." The maximum quantity of fertilizer that can in general be used with advantage is concluded to be an amount that will furnish per acre phosphoric acid, 50 pounds; potash, 15 pounds; nitrogen, 20 pounds.

BEST MODE OF APPLICATION OF FERTILIZERS TO COTTON.

In Alabama experiments in 1887 indicated that broadcasting compost and stable manure gave better results than application in the drill.

In Georgia the results of general experiments indicate that "it is by no means necessary, nor is it desirable, to broadcast the fertilizer when less than 1,500 pounds are to be applied to an acre of corn or cotton or other wide-row crop. If only 500 pounds are to be applied, distribute it in a deep furrow and mix it by running two scooter furrows through it. If more than 500 pounds, then divide the amount between the center furrow and the two listing furrows. Broadcast manuring should, as a rule, be confined to crops that are planted broadcast, as small grain, grass, etc."

The experience and the practice at the stations generally substantiate the conclusion reached in South Carolina that "fertilizers may be indifferently drilled or broadcasted where they are liberally applied, but drilling is to be preferred where small amounts are employed."

BEST TIME OF APPLICATION OF FERTILIZERS TO COTTON.

A number of experiments have been made to test the effects of intercultural applications of fertilizers, the results of which, however, are for the most part discordant and inconclusive.

In Alabama one set of experiments, in 1888, indicated that one application of the fertilizer in the drill before planting gave best results.

[Another, in 1890, was very carefully conducted] in order to test the efficacy of the application of additional fertilizer during the growth of the plant in prolonging its fruiting period and increasing the yield. Two hundred pounds of cotton-seed meal per acre were applied at the second plowing of the cotton, June 18, and covered lightly with the scrape. Two hundred more were applied in the same way at the last plowing, July 30. These were applied to two plats to which 200 pounds of cotton-seed meal and acid phosphate, mixed in equal parts of each, were applied in the drill before planting, and were compared with a third plat to which the same quantity of cotton-seed meal and acid phosphate were applied at planting, but to which no subsequent applications were made. The average increase caused by the additional applications was 339 pounds of seed cotton per acre. The intercultural applications had the effect of continuing the growth and fruitfulness of the cotton after that on plat 3 had ceased to grow.

In 1893, however, it was found that 200 pounds of mixed nitrate of soda and cotton-seed meal applied (to previously fertilized plats) in June was as profitable as 100 pounds in June and 100 pounds in July. The addition of cotton-seed meal as late as August 13 was not profitable.

In Georgia it has been found that marked effects result from intercultural fertilization, or successive applications of fertilizers during the growing season. When a heavy application of a readily available fertilizer is to be made, it would be advisable to divide it into at least two doses, and possibly more.

In Louisiana the conclusion is reached that fertilizers for cotton should all be applied at time of planting. A second and third application is not profitable.

MISCELLANEOUS EXPERIMENTS.

Incidentally to the main objects for which the experiments in the fertilization of cotton were instituted, certain indications on miscellaneous and minor points have been afforded.

The general experience at the stations and elsewhere is to the effect that chemical manures generally, and especially nitrogenous and phosphatic manures, hasten the maturity of the crop. Stable manure in some instances (Arkansas, North Carolina) delayed maturity beyond the fruiting period.

The cumulative effect of manures in the soil is fairly well evidenced in several cases. Nitrogenous manures increased the yield the second season without additional fertilization (Alabama, Arkansas), but not the third season (Alabama). Phosphatic manures increased the yield, without additional fertilization, the second and third seasons (Alabama). The cumulative effects of heavy applications of a complete fertilizer were manifest the second and the third years (Georgia). Floats alone gave a greater increase over no manure the third year after application than in the first or second year (Alabama).

Kainit is recommended as a specific for rust and blight in cotton, to

be used in connection with cotton seed or cotton-seed meal (North Carolina). Kainit appears to retard the appearance of blight (Alabama). Kainit retards the opening of the bolls (Arkansas).

"Marl, alone or in combination with commercial fertilizers, is of no direct value to cotton. Applied upon leguminous crops, which are to be turned under as a preparation for cotton, its indirect value is great" (South Carolina). Air-slacked lime mixed in the drill with acid phosphate and floats had no apparent effect upon the crop (Alabama).

Applications of copperas are without effect upon cotton (South Carolina).

Nitrate of soda should generally be applied with the other fertilizers at the time of planting (South Carolina); but, on the other hand, it may be profitably divided into two applications, the second not to be later than June 1 (Georgia).

The quantity of nitrogen in the fertilizer seems not to affect the relations between the weight of seed and lint (Alabama).

Shallow applications of fertilizers (i. e., at depth of 2 or 3 inches) give better results than deeper applications (Louisiana).

There is no advantage in separating the ingredients of the fertilizer and applying them at different depths (Louisiana).

It is highly important that the fertilizer be well mixed with a considerable portion of soil (Georgia).

The cowpea is an excellent green manuring crop in preparation of land for cotton (Alabama, Arkansas, Louisiana, Georgia). The most profitable method of application is to gather the peas, or cut the vines for hay, and turn under the stubble with addition of the manure from stock fed with the hay (Alabama, Arkansas, Georgia).

GENERAL CONCLUSIONS.

In reviewing the results of the experiments conducted at or under the auspices of the experiment stations, and taking into account the general experience of successful cotton growers, certain general conclusions on the subject of the fertilization of cotton may be accepted as tentatively established:

(1) Cotton is a plant which responds promptly, liberally, and profitably to judicious fertilization.

(2) By judicious fertilization the maturity of the crop may be hastened and the period of growth, from germination to fruiting, so shortened as to materially increase the climatic area within which cotton may be profitably grown.

(3) As is the case with most other crops, the profit from manuring cotton with concentrated fertilizers is much enhanced by antecedent proper preparation of the soil. It pays to bring cotton lands up to a condition of good "tilth" by mechanical treatment, and especially by incorporating in them liberal quantities of organic matter. Upon lands

in such condition fertilizers of all kinds yield more profit, either from small or large applications, than upon lands not so treated.

(4) Renovating crops, and especially the cowpea, furnish an efficient and economical method of bringing cotton lands into condition to respond most liberally and profitably to the application of concentrated manures under cotton. The most profitable plan of employing the cowpea for this purpose on cotton is to gather the peas at maturity, cut the vines for hay, and turn under the stubble along with the manure resulting from feeding the hay to stock and cattle.

(5) Barnyard manure and similar bulky manures are more efficient and profitable as soil renovators than as specific fertilizers for cotton. They should be broadcast liberally and used rather as soil improvers than as immediate fertilizers. The same is probably true of cotton seed, except where the price to be had for the seed at cotton-oil mills justifies the exchange of seed for cotton-seed meal, to be used as the source of nitrogen in a concentrated manure. If, however, only small quantities of such manures are to be had, and it is desired to use them as direct fertilizers, it is more profitable to compost them with acid phosphate (preferably containing a small percentage of potash) than to use them alone. It is more profitable to compost directly in the drill at time of planting than in heaps previously.

(6) Cotton may wisely be assigned a place in a judicious rotation system. Upon lands devoted to staple crops a three years' rotation—small grain, corn (with peas), cotton—is judicious. Each crop in the rotation should be appropriately fertilized. It is in evidence that the cumulative effects of such manuring upon the succeeding crop are marked.

(7) Upon the great majority of the soils of the cotton-growing States it is advisable and profitable to use, as a concentrated fertilizer, a "complete manure," i. e., one containing soluble phosphoric acid, available potash, and available nitrogen, rather than a manure containing only one or two of these ingredients. Nitrogen, however, may probably be advantageously omitted from the concentrated fertilizer, in whole or in part, when the soil has previously been liberally supplied with this ingredient, through barnyard manure, green manuring, etc.

(8) "Soluble" phosphates are very much to be preferred in the fertilizer for cotton to those which are not soluble.

(9) There is no great difference, if any, in the agricultural value and profit, when used in the fertilizer for cotton, of the various soluble potash salts to be had in commerce, except proportionately to the price and content of actual potash.

(10) Of the nitrogen compounds available for use in fertilizers the organic forms (vegetable and animal) are perhaps best suited to cotton, if one form alone be used, although nitrate of soda is probably nearly if not quite of equal value. Further experiments are needed to determine the efficacy of mixing various nitrogen compounds in different proportions.

(11) The most judicious proportions of soluble phosphoric acid, potash, and nitrogen in a complete fertilizer for cotton can not be said to have been as yet determined with entire accuracy. Those suggested by Georgia—nitrogen 1, potash 1, phosphoric acid $3\frac{1}{2}$ —and by South Carolina—nitrogen 1, potash $\frac{3}{4}$, phosphoric acid $2\frac{1}{4}$ —perhaps approximate reasonable accuracy. In the light of present information, perhaps nitrogen 1, potash 1, phosphoric acid $2\frac{3}{4}$ or 3 would not be injudicious proportions for general use.

(12) The amount of concentrated fertilizer which may profitably be used per acre varies widely with the nature and condition of the soil, the seasons, and other circumstances. For an average soil in fairly good condition perhaps the maximum amounts indicated by Georgia (nitrogen, 20 pounds; potash, 20 pounds; phosphoric acid, 70 pounds), or by South Carolina (nitrogen, 20 pounds; potash, 15 pounds; phosphoric acid, 50 pounds), or an approximate mean of the two would be the maximum limit of profitable application. The actual weight of the complete fertilizer furnishing these quantities would, of course, vary with the percentage composition in nitrogen, potash, and phosphoric acid of the materials used to make the fertilizer. If the commercial “ammoniated” fertilizer or other concentrated manure intended for use under cotton should be compounded (as it might very well be, and in some cases is) to analyze approximately—

	Per cent.
Soluble (available) phosphoric acid.....	9
Potash.....	3
Nitrogen.....	3

then 700 pounds per acre of such a fertilizer would be approximately the maximum amount that could judiciously and profitably be used, under ordinary circumstances, upon soil in good condition.

(13) The concentrated fertilizer should be applied in the drill (not broadcast) at a depth of not more than 3 inches, and well mixed with the soil.

(14) All things considered, it is perhaps best in most cases to apply all the concentrated fertilizer in one application at the time of planting. With lands in superior condition, however, or where large quantities of fertilizers are used, it is probably profitable to apply half at planting and half at the second plowing.

These conclusions, it is believed, are justified by the present state of knowledge on the subject of the fertilization of cotton. They may be accepted provisionally and until modified and corrected by the results of further investigations and experiments, such as are now in progress at several of the experiment stations in the Southern States. In view of the importance of the subject and the unsatisfactory state of knowledge concerning it, the writer ventures to suggest that it would probably be wise for some one of the stations of the cotton States to devote a large part of its time and resources to an extensive, thorough, and intimate study of the nutrition, growth, and development of the cotton

plant. It is perhaps not hazardous to conjecture that the results of such study might modify materially the apparent conclusions thus far reached on the subject of the fertilization of cotton.

METHODS OF MANURING COTTON AT PRESENT IN GENERAL USE IN THE UNITED STATES.

The method of fertilizing for cotton at present employed by the Southern cotton grower varies somewhat with differences in soil, climate, capital, etc. The greatest variation, perhaps, is in the preliminary preparation of the land. Some cotton farmers practice green manuring, rotation, composting, etc., with regularity, others irregularly, others not at all. There is much greater uniformity observed in the use of concentrated fertilizers, although here, again, there are wide differences in usage, particularly as to the amount of fertilizer employed. From the time of their introduction until the present, the method of applying chemical manures to cotton has been essentially uniform and the same, viz, in the drill. They are very rarely broadcasted. Neither, indeed, as a rule, are composts, stable manure, or cotton seed. A shallow furrow, varying in depth from 3 to 6 inches—much more frequently 3 than 6—is opened with the plow and the manure applied by hand (generally through a tin tube, known as a “guano horn,” 3 feet long and 2 inches in diameter) or by a mechanical “distributer,” much like a grain drill planter and capable of being set to deliver fixed and uniform quantities. The manure is then “listed” on, i. e., covered with a thin layer of soil to the depth of 1 to 3 inches. The seed are dropped upon this, either by hand or from a “planter,” and covered with soil to a depth usually of 3 inches. The seed are frequently rolled in ashes, or sometimes in acid phosphate or other fertilizer, before planting. The amount of fertilizer used per acre varies greatly. From as little as 50 pounds to as much as 1,000 pounds per acre is used. The average amount used by the very great majority of cotton growers is probably between 175 and 200 pounds per acre. The fertilizer is for the most part the commercial “ammoniated” article, although considerable quantities of acid phosphate (with or without potash) and home mixtures of chemicals are so used. In the case of composts, such as that prepared by the “Furman formula,” for example, the amount used is usually about 400 pounds per acre.

The commercial ammoniated fertilizer sold in the Southern States at the present time will average in composition, approximately—

	Per cent.
Soluble (available) phosphoric acid	9
Nitrogen.....	2
Potash.....	2

Acid phosphates range in content from 12 to 15 per cent of available phosphoric acid, and are often given a small content of potash, ranging from one-half of 1 per cent to 2 per cent.

The home mixture of chemicals is usually constructed on the formula approximately—

	Pounds.
Acid phosphate	1, 200
Cotton-seed meal.....	600
Kainit	200
	<hr/> 2, 000

MANURING OF COTTON IN OTHER COUNTRIES.

Elsewhere than in the United States the culture of cotton is mainly confined to the rich alluvial lands, and a large proportion of the crop is grown without any manuring whatever; still in most countries some use is made of farm manures. Even on the fertile alluvial soils of Egypt, which are so abundantly supplied with fertilizing materials by the overflowing of the Nile, barnyard manure is applied to the extent of 10 to 15 tons per acre, and "generally speaking, except on the richest land, it is acknowledged by experienced growers that the crop repays the cost of application."

In spite of the fact that clover is very generally grown as a preparatory crop for cotton in this country, nitrogenous manures as a rule are the most profitable, because the nitrogen of the soil is exhausted by the large crops of cotton and sugar cane which are grown and which return nothing to the soil, and is also dissipated by the rapid nitrification which goes on under the peculiar climatic conditions of Egypt.

"The time at which the manure is applied varies considerably. Some spread it over the land and plow it in before making the ridges. Others ridge the land and spread it in the furrows, subsequently covering it by splitting the old ridges. Either of these methods is suitable and preferable to the system of applying it after planting, which is perhaps more common than the other. When the cotton is a few inches above the ground, the manure is either spread in the furrows and hand hoed in, or a handful is put under the roots of the young plants. This latter method involves more labor than any other, and has no advantages. Fresh manure is not thought so good as that which has been in the heap for two years, and old manure is always used by the best growers.

"For the production of manure, earth is used as litter, and the composition of the resulting manure depends, therefore, to a considerable extent on that of the earth used. It contains but little water, 5 or 6 per cent being an average. As the result of several analyses made by Dr. Mackenzie, the manure may be said to contain: Nitrogen 0.4 per cent, phosphoric acid 0.25 per cent, and potash 1.5 per cent.

"Following clover, as cotton almost invariably does, it finds except on very poor land a sufficiency of nitrogen, if the fodder crop has been grazed. If cut and removed, the case may be different. After a fallow the land is generally manured, as the land selected for this purpose is of poor quality, and more benefited by its application. No artificial fertilizers are applied in practice, and as yet no experiments of a reliable nature have been made to ascertain their effect."¹

¹ Foaden, MS. article on cotton culture in Egypt in the possession of this Office.

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CULTIVATED VARIETIES OF COTTON.

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INTRODUCTION.

The word "variety" as used in this chapter refers exclusively to the various forms and kinds which are called "varieties" by cotton planters, and is not restricted to the more marked and permanent types which are recognized by the botanists. Of botanical varieties there are but few, while of agricultural varieties there are an almost infinite number, and the names under which the agricultural varieties are known are many times greater than the number of recognizable forms.

Cotton is a plant which sports easily, which responds quickly to any differences in environment, soil, climate, treatment, and fertilizers, and which can be greatly modified in form and habit in a very few successive crops. The flowers are large and open, pollen is produced in great excess and is readily scattered by the lightest breeze, the stigmas are well above the anthers, so cross fertilization is not only common but usual. Seed from the earlier maturing bolls will produce plants yielding a longer lint than will the seed from the later ripening bolls from the same plants. Many varieties which will produce a long, strong, and silky fiber when planted in rich river bottom soil soon lose their superior qualities when grown on the drier and poorer hill lands. A variety which has been grown for some years in the northern belt of the cotton region will mature its entire crop at nearly the same time, while if the same variety be grown for a few years in the southern cotton belt the crop will continue to mature through several weeks, though the total yield may be but little greater. With its natural tendency to vary, and with all these forces to stimulate the plant to a change of form and habit, it is easy to see how varieties may be multiplied indefinitely, even without deliberate action on the part of the cultivator.

In the preparation of this work an effort has been made to trace the origin and history of all the varieties which have been mentioned in the station publications, together with such others as are known to be common in the cotton-growing region of the United States or to possess special value. In many cases the records of certain of these varieties have been very defective, and it has been impossible to secure accurate data from the originators themselves, so that some varieties of greater or less local prominence are not mentioned here. We have found it exceedingly difficult to secure exact data in regard to both the percentage

of lint and the length of staple from different varieties, as in many cases the amount of lint has been estimated from the gin yields, which may vary greatly. In experiments at the Alabama Station,¹ the averages of eight gin yields varied 1.99 per cent, and in one case as much as 5.25 per cent, when two gins of different makes were used on the same varieties of cotton. The percentage of lint also varies with the season and the soil on which the crop was grown. In some cases the length of the staple has been accurately measured from samples taken from the seed by hand, while in others the measurements given have been those of the staple after it had been passed through the gin. In several cases where samples of the same variety have been accurately measured the length has been found to vary greatly, owing to differences in soil and season. The size, weight, and color of the seed appear to be of less value in the identification of varieties than has generally been supposed, as either or all of these may vary with differences of soil and with the individual plants from which they have been taken.

When inconsistencies have been found in the published descriptions of any variety, it has usually been possible to account for them, and to make due allowances. Records which have been extreme and evidently faulty have been ignored, so that the yields and measurements given here are the averages of records which are apparently reliable. It is useless to attempt giving exact characters to such variable plants, but fortunately nearly all of the varieties mentioned in this chapter have been frequently described, and nearly all of them have been grown two or more years under the personal supervision of the writer. In preparing the following descriptions it has been the aim to give the general habit and product of each variety, avoiding both the highest and the lowest extremes:

AMERICAN VARIETIES.

Acme (Allen *Acme*).—From C. B. Allen, Nanachehaw, Miss. Evidently a mixture of some long-staple variety and Sea Island. It is not a hybrid, and does not seem to have any special value.

Allen (Allen Silk, Allen Long Staple, Talbot).—Originated by J. B. Allen, Port Gibson, Miss. Plant vigorous, pyramidal, long limbed; bolls large, round, opening very widely, and sometimes allowing the seed cotton to drop; maturing late; lint 28 to 30 per cent; staple 30 to 35 mm., fine and silky. This, like the Cook, is easily affected by a change of soil or climate, and produces a longer and better staple when grown in the Yazoo Delta than elsewhere.

Alfred.—History unknown, but evidently of the Rio Grande type. Reported only once, from Mississippi.

Alvarado.—History unknown; appears to be Peterkin. Reported only once, from Georgia.

Audrey Peterkin. (See *Peterkin*.)

¹Alabama College Sta. Bul. 33.

Bahama. (See *Texas Storm Proof*.)

Bailey.—Originated by T. J. King, Louisburg, N. C. Plant of medium size, early and prolific for a long-staple variety; lint 28 to 30 per cent; staple 28 to 32 mm. An excellent long-staple variety for uplands.

Banana (Cluster, Hogan, Prout).—Newspaper writers of 1848 to 1850 mention these as being identical, but give no description further than that the bolls were in clusters and that the seed cotton yielded about 31 per cent of lint. The variety seems to have been discarded many years ago.

Bancroft Herlong. (See *Herlong*.)

Bancroft Prolific Long Staple.—Origin unknown; advertised by a Georgia seedsman in 1892, and planted at the Louisiana Station, where its yield was much below the average.

Bancroft Prolific Herlong. (See *Herlong*.)

Barnes.—One of the older varieties. Plant vigorous, short limbed, and inclining to cluster, similar to Herlong in habit; bolls above medium size, maturing late. Probably not now in cultivation.

Barnett.—From Alabama; origin unknown. Plant tall and slender; limbs short; bolls medium size, rounded, not maturing early; lint 30 to 32 per cent, staple 23 to 25 mm. Reported only from Alabama.

Bates Big Boll.—Originated by R. Bates, Jackson Station, S. C., who developed it by repeated selections of choice plants belonging to the Rio Grande type. Plant vigorous, very symmetrical, well branched; bolls rather large, not maturing early; lint 33 to 35 per cent, staple 24 to 27 mm. In 1892 this gave the largest yield of any of the 25 varieties grown at the Georgia Station, and in 1893 ranked fifth among 26 varieties grown at the Mississippi Station.

Bates Favorite.—Of the same origin as Bates Big Boll. Plant very vigorous, branching widely; bolls medium size, maturing late; lint 30 to 32 per cent, staple 24 to 27 mm.

Belle Creole.—The immediate ancestor of the Jethro and described by Col. H. W. Vick, of Vicksburg, Miss., as follows: "Stalk large, tall, and productive; boll large and long; seed commonly flat on one side with an indentation; lint abundant, long, firm, silky, soft, lustrous, and beyond measure more oily than any cotton I have seen."

Ben Smith (Ben Smith Choice, Bush, Smith Standard).—From B. F. Smith, Redwine, La. Plant strong, widely pyramidal; bolls medium size, usually 2 at each joint, not maturing early; lint 32 to 33 per cent, staple 23 to 26 mm. This was grown in Alabama and Georgia many years ago under the name of "Bush," and is probably descended from the Purple Stalk or Red Leaf, which was common in those States from 1845 to 1850.

Big Boll.—From California; history unknown, but supposed to be of Texan origin. Plant medium size; limbs rather long; bolls large, oblong, maturing late; lint 34 to 35 per cent, staple 25 to 28 mm.

Black Seed.—A name applied both to Sea Island varieties and to upland varieties having a smooth seed.

Bob, Bob Silk, Bob White. (See *Ozier*.)

Bolivar County.—A Louisiana variety of the Storm Proof type, maturing early, with 29 to 30 per cent of lint.

Borden Prolific.—Mentioned in South Carolina reports, but no descriptions are given.

Boyd Prolific.—One of the oldest of the improved varieties, having been common in Mississippi in 1847, and is the parent stock of many cluster varieties of recent introduction. The originator, Mr. Boyd, said that it was grown from a single plant found in a field of "common" cotton. Plant upright, slender, moderately vigorous, short limbed; bolls small, round, in clusters, medium in time of ripening; lint 30 to 32 per cent, staple 20 to 24 mm.

Brady.—Mentioned in the report of the North Carolina Station for 1887, but no description given.

Bragg Long Staple.—From T. J. King, Louisburg, N. C. This has every appearance of being a true hybrid between *Gossypium herbaceum* and *Gossypium barbadense*, but as it was grown from a single stalk found in the field of an ignorant negro its parentage is unknown. Plant very vigorous, well branched; bolls large, oblong, maturing late; lint about 30 per cent, and the staple extremely variable in length, the bulk of the fibers being only about 35 mm., while a few—perhaps 5 per cent of those in each boll—reach a length of fully 75 mm. Owing to its mixed character the staple is classed commercially as "short."

Brannon (Little Brannon).—One of the older varieties, originating in Texas many years ago. Plant medium in growth, well branched; limbs short jointed; bolls small, medium in time of ripening; lint 32 to 35 per cent, staple 18 to 22 mm. Belongs to the Rio Grande type.

Brazier Peterkin. (See *Peterkin*.)

Brooks Improved.—A local Louisiana variety, maturing early, with 31 to 33 per cent of lint and a short staple.

Brown.—Originated in Copiah County, Miss., prior to 1848, and said to have been developed by selections from the Sugar Loaf, an early maturing, short-staple variety.

Bush. (See *Ben Smith*.)

Carolina Pride. (See *Early Carolina*.)

Catacaos. (See *Peruvian*.)

Catawba.—From W. R. Davis, Landsford, S. C. A local variety, maturing late, with 35 to 36 per cent of lint and staple 23 to 25 mm. Apparently from the Peterkin.

Chambers.—A South Carolina variety of unknown origin, yielding 31 to 32 per cent of lint, with a staple 22 to 25 mm. Belongs to the Her-long type.

Champion Cluster.—Plant very vigorous, with long limbs; bolls large, oblong, maturing late; lint 30 to 31 per cent; staple 25 to 28 mm. This name is misleading, as the variety does not belong to the cluster type, but is much more like the Mammoth Prolific.

Cherry Cluster (Cherry).—Originated in South Carolina. Plant of medium growth, cone shaped; limbs of medium length; bolls small, round, clustered, maturing early; lint 30 to 32 per cent; staple 18 to 22 mm. Belongs to the same type as the Dickson.

Cherry Long Staple Prolific.—Nearly, if not quite, identical with Cherry Cluster. Originated in the same locality.

Cluster. (See *Banana*.)

Cobweb (Spider Web).—Originated in 1881 by W. E. Collins, Mayersville, Miss., and claimed to be hybrid between Peeler and an Egyptian variety of *Gossypium barbadense*. Plant very vigorous, long limbed; bolls large, somewhat pointed, maturing late; lint 28 to 29 per cent; staple 35 to 40 mm., very fine and silky.

Cochran (Cochran Extra Prolific, Cochran Short Limbed Prolific).—Originated in Georgia by selections from Peerless stock. Plant a moderate grower, slender, short limbed; bolls medium size, round; lint 32 to 33 per cent; staple 35 to 40 mm. Differs but little from the Peerless.

Colthorp Eureka. (See *Eureka*.)

Colthorp Prickle.—The name apparently a mistake for Colthorp Pride.

Colthorp Pride.—From A. S. Colthorp, Milliken Bend, La. Originally grown from a few seeds picked up from the floor of a country store. Plant vigorous, upright, pyramidal; bolls large, oval, maturing late; lint 28 to 30 per cent; staple 28 to 32 mm., fine and silky; seed small and many of them black. Prolific for a long-staple variety.

Cook.—Originated by W. A. Cook, of Newman, Miss., from a single stalk found in a field of "common" cotton in 1884. Plant very vigorous and prolific; limbs irregular, not long; bolls large and long, sometimes 2½ inches in length, maturing late; lint 26 to 28 per cent; staple 35 to 40 mm. Similar to the Allen, and one of the best varieties for rich, low ground.

Cox Royal Arch Silk.—A local variety from Georgia, similar to the Ozier Silk.

Crawford Peerless (Crawford Premium).—From J. M. Crawford, Columbia, S. C. Developed by selections from the Peerless, and practically identical with that variety except that the bolls are usually clustered.

Crossland. (See *Peterkin*.)

Dalkeith Eureka. (See *Eureka*.)

Dean.—A local South Carolina variety.

Dearing (Dearing Prolific, Dearing Small Seed).—Very similar to Herlong. The Southern Live Stock Journal (1887)¹ gives an interview with Dr. J. J. Dearing, Columbus, Ga., presumably the originator or disseminator of this variety. The writer claims to have made all his selections through a number of years with special reference to the per cent of lint, and claims to have attained finally 45.28 per cent of lint "under the test of Prof. H. C. White, State chemist of Georgia."

¹ U. S. Dept. Agr. Library Scrapbook, Cotton and Sugar, pp. 2, 3.

Diamond.—Another of the varieties originated by Col. H. W. Vick; of the Rio Grande type, and differing very slightly from that form.

Dickson (Dixon, Dickson Cluster, Dickson Improved, Simpson).—Mr. Capers Dickson, of Oxford, Ga., writes that this “was originated in this place in 1857 or 1858 by my father, Mr. David Dickson, and was developed from Boyd Prolific cotton by several successive years selections from the seed of that variety. No crossing was practiced, and the variety was entirely the result of careful selections each year. The variety has ever since been kept up in the same way.” Plants vigorous, well branched, pyramidal; limbs short; bolls medium to large, round, clustered, maturing rather early; lint 31 to 32 per cent; staple 23 to 26 mm. One of the most popular cluster varieties.

Drake Cluster.—Originated in 1882 by R. W. Drake, of Greensboro, Ala., and was developed from the Peerless “by selecting the earliest and best matured bolls from the earliest and most prolific plants.” It resembles Peerless in every way excepting that it matures somewhat earlier and the bolls are more clustered. Lint 31 to 33 per cent, staple 22 to 25 mm. One of the most popular varieties for uplands.

Drought Proof. (See *Texas Storm Proof*.)

Duncan (Duncan Mammoth).—From F. M. Duncan, Dallas, Ga. A late-ripening, large-boll, long-staple variety, similar to Mammoth Prolific.

Early Carolina (Extra Early Carolina, Carolina Pride, South Carolina Pride).—An early ripening variety which has been developed by selections from the Dickson and which is very similar to that form.

East (East Improved Georgia).—A long-staple variety similar to the Allen, but maturing a little earlier and having a little shorter staple. Lint 31 to 32 per cent.

Ellsworth.—From W. N. Ellsworth, Wallace, N. C. Plant usually with long and spreading limbs; bolls large, oblong, maturing late; lint 30 to 33 per cent, staple 21 to 24 mm. This is exceedingly variable in its habit of growth and in the character of its lint. Apparently a mixture of two or three varieties.

Ethridge.—From W. B. Ethridge, Downsville, La. Grown from a single plant found in a field of some other variety. Plant of fair size; limbs long and spreading; maturing late; staple fine and silky, 28 to 30 mm.; seed black.

Eureka (Colthorp Eureka, Dalkeith Eureka, Humphrey Eureka).—Originated from a single stalk found on a Louisiana plantation many years ago, and for some time was called Mand Atkins. The plant is very vigorous and prolific; limbs of medium length; bolls rather large, oblong, not maturing early, holding the seed well in wet weather; lint 28 to 30 per cent, staple 35 to 40 mm., very fine, strong, and silky; seed quite small and sometimes black. One of the most popular long-staple varieties.

Excelsior.—Originated in 1883 by C. R. Ezell, Eatonton, Ga., by selections from the New Era. Similar to the Peterkin, though with bolls a trifle larger. Lint 33 to 35 per cent, staple 26 to 30 mm.

Farrar Forked Leaf. (See *Okra*.)

Ferrell Prolific.—From C. B. Ferrell, Montgomery, Ala. Plant medium size, with very long and straggling limbs; very prolific; bolls large, oblong; lint 28 to 30 per cent, staple 30 to 35 mm. Similar to Mammoth Prolific.

Georgia Prolific (Georgia Upland).—Names which are applied to a number of upland short-staple varieties of the Peterkin and Herlong types.

Garber.—A local Alabama variety of the Rio Grande type.

Gold Dust. (See *King*.)

Grayson Early Prolific.—From W. B. Grayson, Grayson, La. Plant medium in size; limbs short, not spreading widely; very prolific; bolls medium in size, somewhat clustered, ripening early; lint 34 to 36 per cent, staple 22 to 25 mm. Resembles Peterkin, but matures earlier.

Griffin.—This remarkable variety was originated by John Griffin, of Greenville, Miss., who developed it by repeated and persistent selections from some unknown long-staple variety. Plant vigorous, with a pale-green leaf, prolific; bolls large, medium in time of maturing; lint 28 to 29 per cent, staple very fine and silky, occasional fibers 70 to 75 mm. The longest and finest staple we have found.

Gunn.—From C. L. Gunn, Temple, Miss. A local variety which does not differ materially from the Rio Grande type.

Hawkins (Hawkins Extra Prolific).—Originated by B. W. Hawkins, Nona, Ga., from a single stalk in a field where mixed seed of Boyd Prolific, Herlong, and New Era had been planted. From the product of this plant repeated selections were made, until the variety had assumed a fairly constant form. The plants are very vigorous, well branched, pyramidal, prolific; bolls medium in size, roundish, medium or early in time of maturing; lint 32 to 34 per cent, staple 18 to 22 mm.

Hays China.—From J. W. Hays, Hays Landing, Miss. Very similar to the Allen, and perhaps the same.

Herlong (Bancroft Herlong, Jones Herlong, etc.).—From E. Bancroft, Athens, Ga. Plant medium in size, well branched, pyramidal, very prolific; bolls medium in size, round, maturing rather late; lint 30 to 32 per cent, staple 20 to 25 mm. A semicluster variety, very popular in Georgia and Alabama. This name is sometimes incorrectly applied to a long-staple variety.

Hightower.—A local Alabama variety, strong growing, bolls very large, and staple of medium length.

Hilliard.—From W. A. Hilliard, Bowersville, Ga. Of the Rio Grande type, and not differing essentially from Peterkin.

Hogan. (See *Banana*.)

Hollingshead.—One of the oldest varieties of which we have any record, it having been grown in the Carolinas in 1818. It was supposed to be of Mexican origin, and seems now to have disappeared.

Howell.—A local Louisiana variety, very similar to Peterkin, but perhaps a little earlier in maturing.

Humphrey Eureka. (See *Eureka*.)

Hunnicut (*Hunnicut Choice*).—Originated by Prof. J. B. Hunnicutt, Athens, Ga., who developed it by mixing seed of Bates, Boyd Prolific, Herlong, Truitt, and other varieties, and planting them in the same field. From the product of these seeds stalks approaching nearest the originator's ideal form were selected for further similar selections which were continued through several years. The plant is large and well branched, branches spreading, prolific; bolls of medium size, roundish, maturing early; lint 30 to 32 per cent, staple 22 to 25 mm.

Improved Long Staple. (See *Jones Long Staple*.)

Improved Prolific.—From A. Borden, Goldsboro, N. C. A local variety, differing but little from the Herlong.

J. C. Cook.—Evidently a descendant of the old Purple Stalk type, and apparently identical with the Ben Smith.

Jenkins (*Jenkins Poor Man's Friend*).—Originated by J. F. Jenkins, Natchez, Miss., by repeated selections from Brannon. Plant strong, pyramidal, prolific; bolls medium in size, oval, maturing early; lint 34 to 36 per cent, staple 22 to 25 mm. One of the best of the Rio Grande type.

Jethro (*McBride Silk*).—Originated by Col. H. W. Vick, of Vicksburg, Miss., between 1830 and 1840, by selections from the Belle Creole, and sent to J. V. Jones, of Herndon, Ga., in 1846, with a request that it be called by its present name. We have been unable to find any description of this variety and can not learn that it is now in cultivation. It is the parent stock of Jones Long Staple, Six Oaks, and a number of other similar varieties.

Jones Herlong. (See *Herlong*.)

Jones Improved (*Jones Improved Prolific*).—Plant of medium size, limbs short and spreading, not very prolific; bolls large, roundish, maturing late; lint 30 to 32 per cent, staple 20 to 24 mm.

Jones Long Staple (*Improved Long Staple*, *Richardson Improved*).—Originated by J. H. Jones, Herndon, Ga. Plant large; limbs long and spreading, prolific; bolls large, oval, pointed, maturing medium or late; lint 29 to 30 per cent, staple 30 to 34 mm. One of the many descendants of the Jethro, and one of the most popular long-staple varieties for the middle and southern parts of the cotton-growing region.

Jones No. 1.—A local Alabama variety of the Rio Grande type, producing 33 to 34 per cent of lint, with a staple 18 to 22 mm.

Jowers (*Jowers Improved*).—Very similar to Peterkin, and probably the same.

Jumbo.—Originated by B. W. Hawkins, Nona, Ga., by selections from the Hawkins, and similar to that variety, though more prolific.

Kelly. (See *Marston*.)

Kieth.—From Alabama. Plant tall, pyramidal; limbs short jointed, prolific; bolls medium in size, roundish, not clustered, maturing early; lint 30 to 32 per cent, staple 24 to 27 mm.

King (Gold Dust, King Improved, Tennessee Gold Dust).—Originated by T. J. King, Louisburg, N. C. Plant of medium size, pyramidal, well branched, very prolific; bolls small, roundish, all maturing early; lint 32 to 34 per cent, staple 25 to 28 mm.; seeds small. The fact that this variety matures its entire crop very early makes it one of the most desirable sorts for the northern cotton belt.

Lewis Prolific. (See *Sugar Loaf*.)

Little Brannon. (See *Brannon*.)

Louisiana.—A name which, like the Georgia Prolific, is applied to a large number of upland short-staple varieties.

Magruder Marvel.—Originated by I. D. Magruder, Russum, Miss., and is a cross secured by fertilizing the flowers of Barnes Cluster with pollen from Golden Prolific. Plant pyramidal; limbs abundant and short jointed; bolls small, round, somewhat clustered, maturing early for a cluster variety; lint 31 to 33 per cent, staple 25 to 30 mm.

Magruder XL.—Originated by I. D. Magruder and secured by fertilizing Peterkin with pollen from the Allen, and in the after fixation of the type by keeping the selection of plants for seed as near as possible to the Peterkin in production and habit, and at the same time preserving the longer staple secured from the Allen. Early and prolific; lint 32 to 34 per cent, staple 25 to 30 mm.

Mallius Prolific.—A local Louisiana variety.

Mammoth Cluster.—From Georgia. One of the older varieties and of unknown origin. Quite similar to Champion Cluster.

Mammoth Prolific.—Another Georgia variety of unknown origin. Plant very strong, well branched, not very prolific; bolls very large, oblong, maturing very late; lint 30 to 32 per cent, staple 26 to 30 mm. Very similar to Duncan, and perhaps the same.

Marston (Kelly).—From Louisiana. Plant of medium growth; limbs short, prolific; bolls fair size, round, maturing late; lint 30 to 31 per cent, staple 26 to 30 mm.

Martin Prolific.—A Louisiana variety, and apparently the same as Marston.

Mastodon.—This name occurs in a list of the varieties grown in Mississippi in 1850, but no description is given, and the variety seems to have disappeared.

Matthews.—From J. A. Matthews, Holly Springs, Miss., who saved the seed from a stray plant found in his garden. Plant very vigorous, pyramidal, with limbs from near the ground; limbs short jointed, very prolific; bolls large, ovate, pointed, maturing early; lint 29 to 30 per

cent, staple 35 to 40 mm. This has given remarkably good yields for a long-staple variety in the northern cotton belt.

Mattis.—From C. F. Mattis, Learned, Miss. Developed by repeated selections from some unknown variety. Plant vigorous; limbs long, short jointed, prolific; bolls clustered, medium in size, maturing rather late; lint 30 to 32 per cent, staple 25 to 30 mm.

Maxey (S. B. Maxey, Meyers, Meyers Texas).—Of unknown origin, but introduced in Texas by Hon. S. B. Maxey. Plants medium in size, well branched, prolific; bolls large, roundish; lint 31 to 32 per cent, staple 30 to 35 mm. Esteemed more highly on bottom lands than on uplands.

McAllister Peerless. (See *Peerless*.)

McBride. (See *Jethro*.)

McCall.—A variety which was somewhat popular in South Carolina about 1880, but which seems now to have been dropped. It belonged to the same group as Truitt and other similar varieties.

McIver.—A local South Carolina variety similar to McCall.

Mexican.—One of the oldest known varieties, having been brought from the City of Mexico to Natchez, Miss., by Walter Burling in 1806, and introduced in South Carolina as early as 1816. It was from this stock that by far the larger proportion of our short and medium staple varieties have been developed.

Mexican Burr.—An old name for the varieties of "Mexican" which produced bolls in clusters, and the original source of many of the present cluster varieties.

Meyers. (See *Maxey*.)

Minter (Minter Prolific).—From J. R. Minter, Laurens, S. C. Originated about 1870 by selections from some unknown variety. Plants large, branching low and widely, prolific; bolls medium in size, round or oval, maturing late; lint 30 to 32 per cent, staple 22 to 25 mm. Quite similar to Herlong.

Moina.—Originated by J. M. Taylor, of North Carolina, about 1873, and described as follows: "This variety is remarkable for the number of its limbs, but they grow too long and slender. Its fiber, in length and fineness, is said to surpass the Peeler. It bears bolls abundantly, but is troublesome to pick and gin, so that its culture is generally abandoned in this section."

Money Bush.—Mentioned as one of the varieties growing in Mississippi in 1850, and probably the same as Banana.

Moon.—From J. Moon, Peytonville, Ark. Originated about 1875 from a single plant showing unusually good staple. Plant strong; limbs long and spreading; bolls large, oval, medium in time of maturing; lint 31 to 33 per cent, staple very strong and silky, 30 to 35 mm.

Multibolus.—This was grown in Mississippi in 1849, and sometimes called "Sugar Loaf." It was a cluster variety which has now disappeared.

Multiflora.—Grown in Alabama in 1849, and said to be similar to the Banana, but with larger clusters of bolls and lighter-colored seeds.

Oats.—Grown and named at the Louisiana Station from seed of an unknown variety purchased at a public gin in 1889. Plant vigorous, sugar loaf in shape, very prolific, maturing early; lint 32 to 34 per cent; staple 20 to 25 mm. Perhaps the same as King.

Okra (Okra Leaf, Farrar Forked Leaf).—One of the older varieties, and mentioned by Southern writers as early as 1837, when it was quite common and somewhat popular, but it soon disappeared from general cultivation. About 1870, C. A. Alexander, of Washington, Ga., found a single stalk in his field, and from its product the variety was again disseminated quite widely from 1885 to 1890, but its culture seems less general now than five years ago. The plant is of medium growth; limbs short and upright; leaves with very narrow lobes; bolls clustered, small, round, maturing early; lint 32 to 34 per cent; staple 24 to 26 mm. The small amount of foliage produced by this variety is said to preserve it from attacks by worms and to hasten the complete maturity of the crop in wet seasons.

Ozier (Ozier Silk, Bob, Bob Silk, Bob White, Tennessee Silk).—From J. D. Ozier, Corinth, Miss. Plants medium size, pyramidal; limbs rather short, moderately prolific; bolls medium in size, oval, ripening early; lint 30 to 32 per cent; staple 25 to 28 mm. Quite popular from 1880 to 1890, but less so now.

Pearce.—Introduced by T. J. King in 1887, and described as an early maturing sort, producing 32 to 33 per cent of lint, but does not appear to have been widely disseminated.

Peeler.—Originated in Warren County, Miss., about 1864. Plant very large and vigorous, branching widely; bolls large, maturing late; lint 30 to 32 per cent; staple very strong and silky, 25 to 28 mm. One of the most widely cultivated varieties.

Peerless (Crawford Premium, Crawford Peerless, McAllister Peerless, Sutton Peerless, The Premium).—Probably of Georgia origin. Plant medium, well branched, pyramidal; bolls small or medium in size, round, sometimes clustered, maturing early; lint 32 to 33 per cent; staple 23 to 27 mm. One of the best of the upland varieties.

Peruvian (Catacaos).—A South American variety of *Gossypium arboreum*, which never matures fruit in the United States.

Peterkin (Audrey Peterkin, Brazier Peterkin, Crossland, Texas Wood, Wise).—Originated by J. A. Peterkin, Fort Motte, S. C., about 1870. Originally a variety with smooth, black seeds, and producing nearly 50 per cent of lint, and developed to its present form by repeated selections of seed from the most prolific plants. Plants of medium size, well branched; limbs short jointed; bolls medium in size, oval, not clustered, not maturing very early; lint 34 to 36 per cent; staple 22 to 25 mm. Seed occasionally black and smooth. There are very few varieties which yield so large a percentage of lint, and this is one of the best of the Rio Grande type.

Peterkin Limb Cluster (Peterkin New Cluster).—Developed by J. A. Peterkin through selections from the Peterkin, and similar to that variety excepting that the bolls are somewhat clustered.

Petit Gulf.—One of the oldest varieties; originated by Col. H. W. Vick, the originator of the Jethro, about 1840. In 1848–49 large quantities of the seed were sent to Georgia and Alabama, and as the shipments were all made from Petit Gulf the variety became known under that name. The plant is large, long limbed, and long jointed, not very prolific; bolls medium in size, ovate, not maturing early; lint 30 to 32 per cent; staple 22 to 25 mm. Boyd Prolific and Dickson are probably descended from this variety.

Pittman (Pittman Extra Prolific, Pittman Improved).—An early maturing, short-limbed, cluster variety, from Louisiana, and which does not differ essentially from Dickson.

Pitt Prolific.—Mentioned as having been grown in Mississippi in 1848, and doubtfully distinct from Banana. No longer in cultivation under that name.

Pollock.—Originated in 1890 by W. A. Pollock, Greenville, Miss., by fertilizing some unknown long-staple variety with pollen from Peerless. A cluster variety maturing a little later than the Peerless, with a staple 35 to 40 mm.

Poor Man's Relief.—A California variety, not distinguishable from Peterkin.

Prolific. (See *Sugar Loaf*.)

Prout. (See *Banana*.)

Queen (Southern Queen).—A local Arkansas variety, very similar to Peterkin, and probably the same.

Rameses.—An old variety, apparently a form of Peerless.

Richardson Improved. (See *Jones Long Staple*.)

Rio Grande.—An early name for the original form of many of the upland short-staple varieties, yielding 34 to 36 per cent of lint, with a staple 18 to 22 mm.

Rod Smith 25 Cent.—Grown in Mississippi in 1849, and described as having "limbs long and slender, bolls slim, very prolific." Not now known.

Roe Early.—A local Louisiana variety, maturing early, with 28 to 30 per cent of lint, and a staple 25 to 30 mm.

S. B. Maxey. (See *Maxey*.)

Sea Island.—This is a native of the West Indies and Central America, and was one of the first varieties cultivated in the United States. In the limited region where it can be grown it is the most desirable variety, as it produces a very long and fine staple, which commands the highest price, but it is seldom profitable when grown more than 50 miles from the Atlantic coast.

Shine Early.—From J. A. Shine, Shine, N. C. An early maturing variety of the Rio Grande type, and differing but little from Peterkin.

Silk. (See *Jethro*.)

Simpson. (See *Dickson*.)

Six Oaks.—Originated by J. V. Jones, Herndon, Ga., the original form being the Jethro, which was sent from Mississippi in 1846. It is similar to the Jones Long Staple, except that the plant is less vigorous, the bolls are not quite so large, and the seed are smooth and black. Lint 28 to 30 per cent, staple 35 to 40 mm.

Smith Standard. (See *Ben Smith*.)

South Carolina Pride. (See *Early Carolina*.)

Southern Hope.—Originated many years ago by Col. F. Robieu, of Louisiana, from seed said to have come from Peru. Plant pyramidal; limbs strong and straight, prolific; bolls large, pointed, maturing rather late; lint 30 to 32 per cent, staple 28 to 32 mm. One of the best types for the southern cotton belt, but maturing too late for northern latitudes.

Spider Web. (See *Cobweb*.)

Storm Proof. (See *Texas Storm Proof*.)

Sugar Loaf (Lewis Prolific, Prolific, Vick 100 Seed).—This is said to have originated in Yalobusha County, Miss., in 1843-44, and to have come from Mexican seed. A cluster variety not now in cultivation.

Sutton Peerless. (See *Peerless*.)

Talbot. (See *Allen*.)

Tarver.—Grown in Alabama as early as 1848, and probably the same as *Sugar Loaf*.

Taylor.—This name is given to at least two distinct varieties, the one known in Alabama under that name having a small boll and a short staple, while that from South Carolina has a large boll and a long staple. In both States the name seems to be only local. The original Taylor of Alabama was claimed to be a cross between the Purple Leaf and Boyd Prolific, showing principally the characters of the former.

Tennessee Gold Dust. (See *King*.)

Tennessee Silk. (See *Ozier*.)

Texas Storm Proof (Bahama, Drought Proof, Storm Proof).—From W. J. Smilie, Baileyville, Tex. Plant tall, with slender and often drooping limbs, not very prolific; bolls large, pointed, maturing late; lint 33 to 35 per cent, staple 23 to 26 mm. The matured seed cotton does not fall from the bolls as readily as in most varieties, and hence its name of "Storm Proof."

Texas Wood.—From D. F. Miles, Marion, S. C. Not distinguishable from Peterkin, and probably identical with that variety.

The Premium. (See *Peerless*.)

Truitt Premium (Truitt Improved).—Originated by G. W. Truitt, Lagrange, Ga. Plants large; limbs long and spreading, prolific; bolls very large, roundish, maturing late; lint 30 to 32 per cent, staple 22 to 25 mm. Very similar to Duncan Mammoth and Mammoth Prolific.

Vick 100 Seed. (See *Sugar Loaf*.)

Welborn Pet.—Originated by Jeff Welborn, New Boston, Tex. Developed from selected plants in a field of Barnes, Jones Big Boll (Jones Long Staple?), and Zellner. Plant erect, slender; limbs short and numerous, very prolific; bolls round, medium in size, clustered, maturing early; lint 31 to 32 per cent, staple 22 to 25 mm. This variety has but little foliage in proportion to the size of the plant, which many cultivators claim is an advantage in hastening early and uniform maturity. One of the best known cluster varieties.

Williams.—An old short-staple variety yielding 33 to 35 per cent of lint and probably identical with Peterkin.

Williamson.—From E. M. Williamson, Dovesville, S. C. Plant not large; limbs short, prolific; bolls small, round, maturing early; lint 30 to 31 per cent, staple 22 to 25 mm.

Willimantic.—Very similar to Duncan Mammoth and Mammoth Prolific.

Willis.—From J. B. Allen, Port Gibson, Miss. Much like Allen in growth, with lint 29 to 30 per cent, and a staple 33 to 37 mm.

Wimberly.—From F. D. Wimberly, Bullards, Ga. Can not be distinguished from Duncan.

Wise. (See *Peterkin*.)

Wonderful (Jones Wonderful).—From J. H. Jones, the originator of several other varieties bearing his name. This is similar to the Jones Long Staple, but has a larger boll and a smaller seed, with a longer and finer staple. Bulletin 20 of the Georgia Station says "it is an excellent type of the upland long-staple varieties, and is more productive and of better staple than any other of the class tested on the station." Lint 28 to 30 per cent, staple 35 to 40 mm.

Zellner.—Probably developed by selections from Boyd Prolific. Plant small to medium, limbs short, prolific; bolls medium or small, round, maturing early; lint 30 to 31 per cent, staple 20 to 25 mm. Very much like Dickson.

In the preparation of the foregoing descriptions great care has been exercised to avoid duplication of varieties under different names, though that has probably been done in a few instances, and no names have been given as synonyms excepting when it has been impossible to separate the varieties either by description or by personal observation.

As showing the instability of varieties it is interesting to note that in the report on cotton of the Tenth Census, 58 varietal names are mentioned. Of these, we have not been able to find that more than 15 have been used during the last ten years, and only 6 of the varieties popular in 1880 are still in common cultivation. Those which have stood the test of the fourteen years since 1880 are Boyd Prolific, Dickson, Herlong, Peeler, Petit Gulf, and Texas Storm Proof.

FOREIGN VARIETIES.

Several varieties of cotton from Japan, Russia, Egypt, and India have been planted in the United States during the last ten years, but

none of them has proved suited to the conditions in this country. The varieties received from Japan have produced very dwarf plants, with small bolls, very small seeds, and a staple not more than 12 to 15 mm., which has been harsh and woolly. The Russian cottons have been uniformly light in yield, short and weak in staple, and usually somewhat colored. The Egyptian varieties are closely related to the Sea Island, and produce an immense growth of stalk.¹ Affi and Bamia are the two varieties which have been most widely tested, but neither has proved to be profitable. Both produce a very long and fine staple, but mature too late for our climate. Seeds of both these varieties were distributed quite freely by the Department in 1892, and since then a number of hybrids between them and some of the upland American varieties have been reported which promise to have considerable value, especially in the southern part of the cotton region. The Indian varieties which have been received have been of two distinct types. One is much like the Japanese varieties in leaf, boll, and lint, but produces a large and spreading plant which bears a very light crop. The other type is evidently descended from the American seed which was sent to India in 1844, and which has become quite common in that country. It is interesting to note that this American cotton which has been grown in India for fifty years has come back to this country practically unchanged, and can not now be distinguished from the Petit Gulf, which was so common in this country from 1830 to 1850.

ORIGINATION OF VARIETIES.

Of course the origin of many of the varieties has been lost in obscurity, but from what has been gathered it appears that the most frequent methods by which new varieties have been originated have been by (1) the selection of individual plants for the original stock; (2) the saving of seed from the earliest maturing bolls, and planting them (usually) on soil which had been highly fertilized; (3) cross fertilization, and (4) the very simple process of changing the name.

PLANT SELECTION.

Every observant planter has noticed the great differences which may be seen among the plants in any field, even though the seed used may all have come from the same source. The different plants will vary in height and vigor of stalks, in length and direction of limbs, in size and shape of leaves, and in the arrangement of bolls on the stalk. Some plants will mature all their bolls within a few days of each other, while other plants will mature slowly and yield successive pickings through several weeks. Any one of these characteristics may be, to a certain extent, strengthened and perpetuated by the saving of seed from plants having the desired characters most strongly developed, and afterwards

¹ See also article on history of cotton, p. 47.

growing them in a field so far removed from other cotton that there will be no danger from cross fertilization. If this process is repeated for a few years, selecting seed each year from those stalks which are nearest the ideal form, the variety will become more and more fixed with each succeeding crop, and each year the entire crop will approach nearer to the desired standard. It has been by this process that many of the more strongly marked varieties like Cook, Dickson, and Welborn Pet have been produced. A bulletin of the Louisiana Station¹ says :

First, determine what you want—have a fixed standard in view. Then go to your plants, whatever they may be, and select carefully that one which comes nearest to filling these requirements. Then carefully gather the seeds of that plant, and in the proper season plant them. Again exercise the same care in selecting your seed and repeat the operation until you finally reach the object required. It takes time for this, and there are frequent disappointments. Do not misunderstand us as recommending every farmer to go into the business of originating varieties. At the most, whether it be by selection or by hybridizing, it requires more time and patience than many of us possess. But we do urge upon each and all the importance of exercising the greatest care in the selection of their seed. The day is not far distant, in fact is even here, when the kind of seed used is quite an item in the profit and loss account of each farmer, and he who neglects it is bound, sooner or later, to go to the wall to make way for a more careful successor.

SAVING SEED FROM EARLY MATURING BOLLS.

The second method named, that of saving seed from the earliest maturing bolls, the “first pickings,” is practiced largely, and it is to this process that we owe many of the widely known varieties like Drake Cluster, Jetfro, and Southern Hope. The higher fertilization and cultivation which seed saved in this manner usually receive also tends to lengthen the fiber, make the plants more productive, and so assists still further variation from the original type. Varieties produced in this manner, though usually superior to the original stock, are not strongly marked, and the improvement is less permanent than is that which may be produced by the selection of individual plants. In fact, these should hardly be recognized as distinct varieties, and in the naming of such the word “improved” is often prefixed to the name of the parent variety.

CROSS FERTILIZATION.

When it is desired to combine the good qualities of two varieties in a single stock, the work can be accomplished best by cross fertilization, and it is more than probable that a large proportion of the varieties which have come from single plants have really originated accidentally in this manner. It is equally true that many of the so-called “crosses” and “hybrids” are not such, but are merely sports.

Although cross fertilization is the surest method for the production of new varieties, it is largely work in the dark, as the plants resulting from the crosses may fail to show the good qualities of either parent and have all the weak points of both. Out of a hundred crosses which

¹ Louisiana Sta. Bul. 26

may be grown, it is seldom that more than one or two plants will show the combination desired, and even when a promising plant does appear its character is not yet fixed, and several generations must be grown before it will assume its permanent form and demonstrate its real value. Although the plants from a single line of crosses, as fertilizing Peterkin with Allen, will vary widely, still it is a general rule that the character and habit of the future plant will be more like those of the female parent, while the fruit, the boll and its contents, will be more like those of the male parent.

The flower of the cotton plant is so large and develops so rapidly that cross fertilization is very easily secured. Flowers which are to be fertilized should be among those which are developed early in the season, and should always be those on healthy and vigorous plants. The flowers to be operated upon should be selected late in the afternoon, as it is only at that time that they are in the proper condition for the work. One side of the unopened bud should be split lengthwise with a sharp knife having a slender blade, and the stamens removed. The anthers, the fertilizing parts of the stamens, will be found well developed and standing well away from the pistil, though not yet so matured as to be discharging pollen. These can be readily separated from their supports by a few careful raking strokes of the knife, and the emasculated flower should then be inclosed in a paper bag to prevent access of pollen from unknown sources. The following morning the pistil will be fully developed and ready to receive pollen. A freshly opened flower from a healthy plant of the variety which it is desired to use in making the cross is picked and carried to the plant which was treated the previous evening, the bag is removed from the prepared flower, and, by means of a camel's hair brush, pollen is dusted over the end and upper part of the pistil. The paper bag is then replaced and allowed to remain two days, after which it should be removed. If more than one variety is used to furnish pollen for different flowers, a tag bearing the name of the variety from which the pollen was taken should be attached to the limb just below each fertilized flower. When the fertilized bolls are matured, those from each line of crosses should be saved separately and the seed from each planted separately the next season. The plants resulting from such crosses will vary greatly, even when all come from seeds from a single boll. Any which appear to be wanting in vigor should be destroyed as soon as their weakness is shown, and only healthy and vigorous plants allowed to mature. When the plants approach maturity they should again be examined carefully, and all which show a want of fruitfulness, a tendency to disease, or any other undesirable character should be removed. At the same time those plants which approach most nearly to the ideal, i. e., those which are strong and vigorous, which produce the largest number of bolls, and which have the longest and best fiber and the largest proportion of fiber to seed, should be marked, and the seed from each of these saved

separately. As the earlier maturing bolls always produce the better crop, the later ripening bolls from the selected plants should be discarded.

The following season the seed from each of the selected plants should be planted separately, and then, and not until then, will the planter be able to form an intelligent estimate of the true value of his crosses.

It will be seen that such work requires care, judgment, and patience, but it is the only plan by which the special characteristics of different varieties can be combined in one; it is the only way by which the planter can secure such a definite modification of the plant as he may wish, and it establishes varieties having greater permanency of character than can be produced in any other manner.

CHANGE OF NAME.

By far the larger part of the names of varieties now in cultivation are simply synonyms of other names. Changes of name are commonly made by using the name of the person from whom seed is purchased, giving a new name to an old variety for advertising purposes, substituting a local name for one in general use, or transferring names from one locality to another. Often several varieties receive the same name.

IMPROVEMENT AND DETERIORATION OF VARIETIES. •

The cultivated cottons of to-day are very different from the original form of *Gossypium herbaceum*, which gave only 28 to 30 per cent of lint, with a staple 20 to 30 mm. long. The proportion of lint has been greatly increased, reaching as high as 36 and even 40 per cent in some varieties, while the length of staple has increased correspondingly, sometimes reaching fully three times its original length. In but few varieties, however, have we secured any marked increase in both percentage of lint and length of staple, and it is in that direction that we should look for improvements in the future.

The tendency of the plant to vary from the typical form of any variety has been mentioned on another page, and it should be borne in mind that the natural tendency of this variation will be back toward its original form rather than in any other direction. Abnormal fruitfulness is always secured at the expense of vitality, and the original form, producing a smaller amount of fruit, will have the greater vitality, and so a greater prepotency, than will the more fruitful and more desirable, but weaker, plants. If, then, any improved variety is to be kept up to its present standard, constant care in the selection of seed is essential. The seed from all plants which show degeneration should be rejected, and only those from typical plants should be saved. Whenever these precautions are neglected, degeneration is sure to follow, and we soon hear complaints that the variety has "run out." All of our present varieties are artificial, and have been produced by artificial methods, which must be continued as long as the variety is to be maintained. Continued intelligent selection and cross fertilization may work a gradual

improvement, while neglect in the selection of seed is sure to result in degeneration and reversion to the original form. It is for this reason that planters are so often disappointed with the results secured from new varieties for which extravagant claims have been made by their originators. These new varieties may do all that is claimed for them during the first one or two years, but afterwards, in many cases, deteriorate rapidly, and their originators are denounced as frauds.

The too common method of saving seed for planting is to take a sufficient number of bushels just as they come from the gin, or, perhaps, to buy them from an oil mill. No attention has been given to the selection of the individual plants from which these seeds came, and those from the poorest, least prolific, and latest maturing are all taken together with those from the best. Seed from the less prolific plants will have greater vitality and so produce stronger plants than those from the more prolific individuals, and when this process is repeated for a few generations it is sure to result in a marked decrease in yield and a deterioration in quality. In speaking of the instability of varieties, W. A. Cook says:

I can take any of the so-called distinct varieties of cotton and in a few years develop all the known varieties from it. In other words, they will develop themselves in the course of time. All that is necessary is to watch the field from year to year, and when a "sport" is noticed, save the seeds and plant them by themselves.

J. Griffin, the originator of the Griffin variety, writes:

Since 1868 I have not omitted a single year in my selections, which are guided by length, fineness, prolific tendency, earliness, and, lately, smallness of seed, to humor planters. I can now see that it will take more than the remainder of my life to complete my work, as the variety still improves as at the first.

J. H. Jones, of Georgia, says:

There is no other plant known in our agriculture which deteriorates so rapidly and requires such a rigid selection of seed to keep it up to a standard as does cotton.

The Sixth Report of the Mississippi Station says:

The particular variety to be selected * * * depends more on the care with which the seed has been selected during the last two or three years than upon its original source, and without constant care in the selection of seed any variety will soon "run out." The first pickings will give better seed than will the later pickings; and if the seed be saved from the best stalks only, the practice will soon work a marked improvement in any variety. Even when this can not be done for the entire crop, it will be easy to secure enough of this selected seed to plant a small field, which will produce sufficient seed for the entire crop of the second season. It has been by the following of this plan that nearly all of our best varieties have been developed, and the superiority of any variety is usually a very good measure of the care and judgment which were exercised in selecting the seed plants of the original stock.

CLASSIFICATION OF VARIETIES.

With so many varieties which differ from each other only slightly, and with their differences those of degree rather than of kind, and all of them exceedingly unstable, it is impossible to classify them by any natural and fixed characters, or even to assign limits to different groups which will not sometimes separate varieties which resemble each other closely, and any grouping must be purely arbitrary.

If classified according to the proportion of lint to seed, they may be placed in three groups, as follows:

(1) Those having less than 30 per cent of lint, including Allen, Bailey, Bragg, Cobweb, Colthorp Pride, Cook, Eureka, Ferrell, Griffin, Jones Long Staple, Matthews, Roe Early, Six Oaks, Wonderful, and Willis.

(2) Those having from 30 to 34 per cent of lint. This group will include more than one-half of all our recognized varieties, as follows: Barnett, Bates Favorite, Ben Smith, Boyd Prolific, Chambers, Champion Cluster, Cherry Cluster, Dickson, Drake Cluster, Ellsworth, Hawkins, Herlong, Hunnicutt, Jones Improved, Jones No. 1, Kieth, King, Magruder Marvel, Magruder XL, Mammoth Prolific, Marston, Mattis, Maxey, Minter, Moon, Oats, Okra, Ozier, Peeler, Peerless, Petit Gulf, Southern Hope, Truitt Premium, Welborn Pet, Williamson, and Zellner.

(3) Those having 34 or more per cent of lint, including Bates Big Boll, Big Boll, Brannon, Catawba, Excelsior, Grayson, Jenkins, Peterkin, Rio Grande, and Texas Storm Proof.

If the same varieties are classified according to length of staple only, they may again be placed in three groups, as follows:

(4) Those having a staple less than 25 mm., or "short-staple" varieties, including Barnett, Ben Smith, Boyd Prolific, Brannon, Catawba, Chambers, Cherry Cluster, Dickson, Drake Cluster, Ellsworth, Grayson, Hawkins, Herlong, Hunnicutt, Jenkins, Jones Improved, Jones No. 1, Minter, Oats, Peterkin, Petit Gulf, Rio Grande, Texas Storm Proof, Truitt Premium, Welborn Pet, Williamson, and Zellner.

(5) Those having a staple of from 25 to 30 mm., or the "medium-staple" varieties, including Bates Big Boll, Bates Favorite, Big Boll, Champion Cluster, Excelsior, Kieth, King, Magruder Marvel, Magruder XL, Mammoth Prolific, Marston, Mattis, Okra, Ozier, Peeler, Peerless, and Roe Early.

(6) Those having a staple exceeding 30 mm., or the "long-staple" varieties, including Allen, Bailey, Bragg, Cobweb, Colthorp Pride, Cook, Eureka, Ferrell, Griffin, Jones Long Staple, Matthews, Maxey, Moon, Six Oaks, Southern Hope, Willis, and Wonderful.

Group 1 has 15 varieties, of which 14 belong in group 6 and 1 in group 5. The varieties in this group, with the doubtful exception of Roe Early, of which we are able to find but one record, are what are commonly called "long-staple" varieties, and are almost uniformly varieties in which the plant is large and vigorous, the limbs long and spreading, the bolls large, and which usually mature late.

Group 2 has 36 varieties, of which 20 belong in group 4, 13 in group 5, and 3 in group 6. In this group we have what may be termed the normal type of cotton, with a slight increase in both percentage of lint and length of staple, some varieties showing an improvement in only one direction, but nearly all showing that both the amount and quality of the fiber have been materially bettered by cultivation.

Group 3 has 10 varieties, of which 7 belong in group 4 and 3 in group

5. In this group we have varieties in which the percentage of lint has been greatly increased with but little improvement in the character of the staple, nearly every variety in the group having a staple less than 25 mm. in length.

Group 4 has 27 varieties, of which 20 belong in group 2 and 7 in group 3.

Group 5 has 17 varieties, of which 13 belong in group 2, 3 in group 3, and 1 in group 1.

Group 6 has 17 varieties, of which 13 belong in group 1 and 3 in group 2.

It will be observed that the correspondence between group 1, producing less than 30 per cent of lint, and group 6, having a staple more than 30 millimeters in length, is very close, only 3 of the "long-staple" varieties yielding more than 30 per cent of lint, and only 1 variety which yields less than 30 per cent of lint having a staple less than 30 mm. The correspondence between the other pairs of groups—2 and 5, 3 and 6—is less marked, but still shows a strong tendency toward a decrease in length of staple as the percentage of lint is increased.

If classified according to time of maturity, the varieties may be grouped as follows:

Classification of varieties according to time of maturity.

Early.	Medium.	Late.
Bailey. Brooks Improved. Cherry Cluster. Dickson. Drake Cluster. Early Carolina. Grayson Early Prolific. Hunnicuttt. Jenkins. Kieth. King. Matthews. Oats. Okra. Ozier. Peerless. Pittman. Welborn Pet. Williamson. Zelluer.	Barnett. Bates Big Boll. Ben Smith. Boyd Prolific. Brannon. East. Eureka. Griffith. Hawkins. Herlong. Jones Long Staple. Magruder Marvel. Maitis. Moon. Peterkin. Peterkin Cluster. Petit Gulf. Pollock. Six Oaks.	Allen. Barnes. Bates Favorite. Brag. Long Staple. Catawba. Champion Cluster. Cobweb. Colthorp Pride. Cook. Ellsworth. Ethridge. Jones Improved. Mammoth Prolific. Marston. Minter. Peeler. Southern Hope. Texas Storm Proof. Truitt Premium. Willis.

The Arkansas Station¹ classifies varieties according to habit of growth, placing them in two groups—the "long limb," which is characterized by its long and spreading branches, want of prolificacy, large bolls, late maturity, and long staple; and the "short limb," characterized by its short branches, medium or small bolls, prolificacy, early maturity, and short staple. The same article also says that the varieties of the "long-limb" group grow slowly, require less readily available plant food and less frequent cultivation than the "short limb," which is regarded as being a direct product of high culture and especially

¹ Arkansas Sta. Rpt. 1893.

suitable for high farming. It also states that the short-limbed and cluster cottons can not be made to produce as long a fiber as the long-limbed varieties, and suggests that in many cases length of staple should be sacrificed for quantity, or more strictly speaking, that it is often better to sacrifice length of staple in order to secure an early matured and increased crop which may be picked at a low cost, and before it is damaged by winds and rain.

RELATIVE VALUES OF VARIETIES.

In deciding upon the relative values of different varieties of cotton the planter will be guided wholly by the number of dollars per acre which each variety will bring, and what variety he shall choose is a question to which no definite reply can be given. The same variety will give different yields in different years, on account of early or late frosts and the amount of rainfall in different months, especially from August to October. Some varieties are more liable to suffer from insects than are others. Some varieties which make a long, fine, and silky staple when grown on rich, damp, and alluvial soil, such as is found only along the larger rivers, are of but little value when planted on the high and dry uplands. Some varieties respond much more quickly than others to applications of fertilizers; some produce a moderate crop under almost any conditions, while others give an enormous yield when all the surroundings are favorable but fail miserably when planted on unfavorable soils or with unfavorable climatic conditions. The relative prices of the lint from different varieties vary greatly from one year to another. In 1887 the lint from the long-staple sorts, those having a staple 35 mm. or more in length, sold in the New Orleans markets for nearly or quite double the prices paid for the short staples, or those having a staple 20 to 30 mm. in length. Since then, however, the prices have been approaching each other more and more closely, until now the difference is only from 10 to 20 per cent. The yield in pounds per acre for the short-staple varieties is always larger than for the long-staple sorts, though the amount of this difference will vary greatly with the localities where the crops are grown. In the hill regions the yield of the short-staple varieties is always much the greater, and is often fully double that of the long staples, and even on the lowlands of the southern portion of the cotton belt, the region best suited to the growth of the long staples, there is always a difference of yield in favor of the short staples. The long-staple varieties need not only a rich soil but the best of care in cultivation, handling, and ginning, and require the highest intelligence and skill for their proper management.

Although some of the short-staple varieties are late in maturing their crop, still there are varieties which do mature much earlier than any of the long-staple varieties. In the southern portions of the cotton-growing region, where the season is long, this is a matter of little moment, but it becomes a point of the greatest importance in more northern latitudes, where the season without frost is not sufficiently long to

mature any but the earliest ripening sorts. No variety of cotton will be profitable to the planter if it does not have a sufficiently long growing season in which to mature its entire crop, and it is safe to conclude that the short-staple varieties will usually be found the more profitable in that part of the cotton region north of latitude 32°.

The character of every plant is fixed in the seed from which it comes, and the peculiar vital force in each seed is determined to a great degree by the conditions surrounding the parent plant. Heredity plays an important part, but is not so strong as to wholly overcome the modifying influences of climate, soil, and season when these are acting in the same direction through generations. The law of the survival of the fittest applies to cotton as elsewhere, and when assisted by intelligence will soon develop in each region the special type of plant best suited to that particular locality. A reference to the descriptions of the long staple varieties will show that of the 17 varieties named in group 6 (p. 217), 1 is probably a hybrid with Sea Island, and that the histories of 2 others are unknown. Of the remaining 14, 6 originated in Mississippi, 3 in the adjoining State of Louisiana, and 3 others were developed in Georgia from seed sent there from Mississippi, so that the low alluvial soils and moist climate of the Mississippi River region have furnished the necessary conditions for the development of 12 out of the 14. In no other part of the cotton-growing region are the long-staple varieties grown so largely, and nowhere else do they approach so closely to the yields made by the short-staple sorts. Similar conditions exist along a few of the larger rivers in other sections, and in such locations the long-staple sorts will be equally successful, but such areas are quite limited in extent. A long growing season, a rich soil, and a humid atmosphere are all essential to their success, and it is useless to plant them where all of these conditions do not exist.

The great increase in the amount of Sea Island cotton grown in this country, together with the rapidly increasing exportation of long staple cotton from Egypt, will do much to keep down the prices of the upland long-staple varieties, and it is doubtful whether they will ever again be as profitable as formerly for general cultivation.

North of latitude 32° the growing season is so short that only those varieties which make their entire growth quickly can be grown with profit. Among the earliest ripening varieties are Cherry Cluster, Dickson, Drake Cluster, Hawkins, Hunnicutt, King, Peerless, and Peterkin. Of these 8 varieties 6 belong to group 4, having a staple less than 25 mm. in length, and in only 2 of them—King and Peerless—do we find representatives of group 5, with a staple from 25 to 30 mm. All belong to group 2, having from 30 to 34 per cent of lint. We may therefore safely conclude that the best varieties for the northern part of the cotton region will be such as have a short or medium length of staple, together with a fair but not excessive percentage of lint. The long-staple sorts and those producing more than 34 per cent of lint mature too late to be grown with safety in this region.

In the middle and southern portions of the cotton belt early maturity is less important, though often an advantage by enabling the planter to gather the crop without injury from rains, which are often heavy and frequent in November and December. There the principal point to be considered is which variety will yield the greatest number of pounds of lint per acre, as there is very little difference between the selling prices of 20 mm. and 30 mm. staples. The common varieties which may be relied upon to produce 34 per cent or more of lint are Bates Big Boll, Brannon, Catawba, Excelsior, Jenkins, Peterkin, Rio Grande, and Texas Storm Proof. Of these 8 varieties 6 belong in group 4, those having a staple of less than 25 mm., and the other 2, each of which produces only 33 to 35 per cent, belong in group 5. An excessive percentage of lint and a long or even a medium length of staple are never found in the same variety. The difference in yield per acre between the short and the medium staple varieties is not marked, though there appears to be a slight difference in favor of the shorter staples.

We have records of 881 tests of 59 varieties which have been made at the Southern experiment stations during the last seven years, each variety having been tested three or more times. By taking the average yield of all the varieties tested at each station during each year as 100, the relative yield and rank of the different varieties is found to be as follows:

Relative rank as regards yield of different varieties.

[The average for all varieties taken as 100.]

Variety.	Number of tests.	Maximum.	Minimum.	Average.	Variety.	Number of tests.	Maximum.	Minimum.	Average.
Haggerman	3	149	101	131	Hawkins	34	148	57	101
Texas Wood	9	143	105	123	Ozier	17	119	45	100
Taylor	7	177	96	119	Southern Hope	34	139	68	99
Brannon	9	140	102	117	Ellsworth	8	125	54	99
Peterkin	53	171	70	116	Oats	7	120	65	99
Fishburn	4	149	95	116	Cochran	6	130	76	98
Thomas	5	157	101	115	Eureka	9	140	78	98
Kieth	5	134	100	114	Chambers	3	101	89	97
Drake Cluster	6	152	88	112	Ethridge	3	117	68	97
Excelsior	10	154	84	109	Hays China	5	114	81	97
King	44	173	76	108	Jowers	11	128	76	97
Boyd Prolific	10	156	68	107	Willis	3	112	72	97
Truitt Premium	45	161	40	106	Cherry Long Staple	14	132	74	96
Barnett	6	126	83	106	Jones Long Staple	26	136	57	96
Duncan	8	129	86	105	Peeler	8	108	81	96
Hunnicutt	8	134	74	105	Petit Gulf	15	132	46	96
Jones Improved	23	135	82	105	Okra	28	124	67	95
Peerless	36	143	76	105	Allen	34	144	52	94
Texas Storm Proof	27	176	69	104	Bolivar County	3	116	83	94
Early Carolina	7	126	83	104	Rameses	6	105	83	94
Bailey	4	132	79	104	Zellner	9	105	44	94
Rogers	3	122	91	104	Cobweb	5	103	87	93
Dickson	21	141	74	103	East	3	113	75	92
Deering	19	150	80	103	Cherry Cluster	13	123	55	90
Peterkin Cluster	5	124	80	103	Matthews	6	111	62	88
Shine Early	18	132	61	103	Colthorp Pride	3	99	71	87
Welborn Pet	37	185	73	103	Cook	12	123	56	85
Ben Smith	11	139	73	102	Six Oaks	4	126	57	82
Dean	3	165	99	102	Wonderful	4	113	44	80
Crawford Peerless	20	155	58	101					

It should be remembered that the table above refers to the relative yield of lint only, and does not bear on the value of the lint. The figures have been compiled from the results secured at 8 different experiment stations during seven years, and show the wide variations which may occur with any variety when grown in different localities and in different seasons, and illustrate very forcibly the statement made on a previous page that no one variety can be regarded as being the best for all soils and for all seasons. Of the varieties which have been tested 25 or more times, so that their relative values may be regarded as being fairly well known, Peterkin, King, and Truitt Premium take the highest rank, followed closely by Peerless and Texas Storm Proof. Of these, Peterkin, Texas Storm Proof, and Truitt have a staple of less than 25 mm., while King and Peerless have a staple of from 25 to 30 mm. King, Peerless, and Truitt yield from 30 to 34 per cent of lint, and the other two—Peterkin and Texas Storm Proof—yield more than 34 per cent. It is also significant that the 5 varieties at the bottom of the list are all long-staple sorts, which produce less than 30 per cent of lint. As the table has been made up from the results secured at stations in both the northern and the southern parts of the cotton belt, it is possibly misleading in that it does not show what varieties have given the best results at either extreme, but it probably indicates very closely the relative standing of the different varieties in the central belt. Of the 5 varieties named 2 are early, 1 is medium, and 2 are late in time of maturity. All are "short" or "medium" staple, but it should be noted that there is no experiment station located in what is known as the "Delta" country along the Mississippi River, the region which is universally recognized as being best adapted to the growth of the long-staple varieties.

As showing how yields may vary, even in a single locality, the following table is given from the results secured in the work of five years at the South Carolina Station, where the same varieties were used continuously; the figures indicate the relative rank as regards yield of each variety:¹

Relative rank as regards yield of different varieties.

Variety.	1884.	1885.	1886.	1887.	1888.	Average.
Peterkin.....	1	1	1	1	4	1
Jones Improved.....	2	5	8	2	11	3
Dickson Improved.....	3	3	3	4	13	2
Cobweb.....	4	11	6	11	12	8
Thomas.....	5	4	5	5	7	2
New Texas.....	5	7	12	7	6	7
Ozier.....	6	9	7	10	3	6
Common.....	7	6	4	9	5	4
Duncan.....	8	10	2	13	1	5
Richardson.....	9	12	9	12	10	11
Dickson Cluster.....	10	2	10	6	9	7
Hays China.....	11	8	13	8	8	9
Crawford Peerless.....	12	13	11	3	12	10

¹South Carolina Sta. Rpt. 1888, p. 218.

These variations are nearly or quite as great as when the cottons are grown in different States, as may be seen by the following table, showing the relative rank as regards yield of eleven varieties, grown in four different States as reported by the Arkansas Station:¹

Relative rank as regards yield of different varieties.

Variety.	Arkansas.	Georgia.	Louisiana.	Mississippi.
Peerless	1	5	3	8
Shine Early	2	.....	8	7
Mammoth Prolific	3	6	.....	5
Hawkins	4	2	4	9
Deering	5	.....	.....	.....
Herlong	6	4	5	10
Allen	7	7	6	6
Jones Long Staple	8	9	2	4
Peterkin	9	1	1	3
Southern Hope	10	8	.....	2
Truitt Premium	11	3	7	1

The Alabama College Station reports² as a result of examinations of 25 varieties that the strongest cotton fibers were produced by Truitt, the largest by Barnet, the smallest by No. 1 (Peerless), Hawkins Improved, and Peterkin, the longest by Okra Leaf, the shortest by No. 2 (Peerless), and the best twisted by Truitt, Rameses, and Cherry Cluster; the largest percentage of fiber per boll was produced by Welborn Pet, Okra Leaf, Peterkin, Hawkins Improved, and King Improved, in the order named; the largest percentage of seed per boll was produced by Zellner, Rameses, Southern Hope, and Truitt, in the order named; and the best grade of cotton, taking all things into consideration, is Cherry Cluster, the second best Truitt.

Alabama Canebrake Station, in reporting a test of 13 varieties, says:³ "Peerless and Welborn were the best types of cluster cotton. The greatest yield was made by Peerless, Peterkin, and Texas Storm and Drought Proof." The same station, in reporting tests of 15 varieties in 1891, says: "Peterkin and Peerless are the most desirable varieties."

The directions in which we must look for a further improvement in varieties will vary somewhat with the latitude where the crop is to be grown. In order to be desirable for any locality the crop must mature before the plants are killed by frost, so that, at least for the northern cotton belt, it is essential that complete and early maturity be secured. No variety which does not mature fully three-fourths of its crop before the first of October should be grown north of latitude 32°, and even south of that region early maturity is desirable as enabling the crop to escape probable injury and loss from October storms, though it is not as essential as farther north.

Individual plants of any variety differ from each other so widely that it is an easy matter to select certain ones which have characteristics

¹ Arkansas Sta. Bul. 18.

² Alabama College Sta. Bul. 13 (n. ser.).

³ Alabama Canebrake Sta. Buls. 11 and 14.

making them more desirable than are the majority of those in the same field. An ideal plant should be vigorous in its growth and wholly free from disease. The branches should be sufficiently strong and rigid, so that when they are loaded with green bolls they will not touch the ground. There is a great diversity of opinion as to the relative productiveness of the "cluster" and the "limbed" varieties, both styles of growth having their warm supporters. Many planters claim that the cluster or short-limbed varieties are best on deep and rich soil, while the longer-limbed sorts are superior for lighter soils. The results which have been secured in a large number of comparative tests, however, do not seem to show any foundation for this opinion, and indicate that the differences, if any, are attributable to other reasons than the mere length of the limbs. The short-limbed and cluster sorts can be planted more closely than can those varieties having longer and more spreading branches, but usually have smaller bolls, and none of the cluster varieties produce a long staple. Many of the cluster varieties have sharp points to the bolls, which make them unpleasant to pick, though this objection does not apply to all. Most of the cluster varieties mature early, though none of them mature as early as do some of the medium and short-limbed sorts, and a few mature quite late. The general results of the tests made show the cluster varieties to be better adapted for cultivation in the middle and southern cotton region than in the extreme northern belt. The bolls should be of good size, and a cross section should show a circle and not a triangle with rounded corners. When mature they should point downward rather than upward, so that rain and heavy dews will not enter and rot the contents; and they should also open widely enough to permit easy picking, but not enough to allow the seed cotton to drop to the ground. It is of no advantage to have more than three or four divisions or "locks" in a boll, as when spherical in shape, and with a given diameter, its contents can be no greater in six sections than in three. The bracts at the base of the boll should be small, so that they will not be in the way and become entangled with the seed cotton in picking. The lint should be pure white in color, strong, even, silky, uniform in length and twist, and should be easily separated from the seed in ginning. The staple should be not less than 25 mm. in length, and if 30 mm. can be secured it will be still better, though it will not be advisable to sacrifice a larger yield for a longer staple so long as the present relative prices of the long and short staples are maintained.

With early maturity and a medium length of staple secured, the only additional feature which need be considered is how to secure the greatest possible yield of lint per acre. It is often claimed that the larger the percentage of lint to seed cotton the more valuable the variety. This belief has no foundation in fact, and is really the reverse of true, provided the total yield of lint per acre remains the same. A crop of 500 pounds of lint and 1,100 pounds of seed per acre is certainly more

valuable than the same crop of lint with only 900 pounds of seed. At present prices the seed is an important part of the crop, and if the yield can be increased without detriment to the total yield of lint it will add just that much to the value of the entire crop. In speaking of this matter the Georgia Station says:¹

It may be said by way of caution that there is no necessary relation between the yield of lint per 100 pounds of seed cotton and the actual yield of lint per acre. A variety may yield a high percentage of lint, calculated on a given weight of seed cotton, and yet yield less lint per acre than another variety. It is probably more a question of seed than of lint. As the seed contains nearly all of the valuable elements taken from the soil, it is but reasonable to expect that a large yield of seed per acre will be attended by a correspondingly large yield of lint. We have but little doubt that some varieties that are popular with the mass of farmers because of their percentage of lint compared to seed simply produce less seed per acre instead of more lint per acre. It remains true, however, that a small-seeded variety—small in size and small in percentage of the whole—is better for poor land and low culture than a variety having a naturally large seed and a smaller percentage of lint.

It is a well-established fact that large seeds will produce stronger and more vigorous plants than small seeds of the same variety. Cotton is no exception to the rule, and if bred to produce small seeds it will be at the expense of the size, vigor, and health of the plant. A heavy yield of good lint is the main object to be attained, but this will not necessarily follow from a decrease in the size of the seed. Of course, the planter can not afford to increase the percentage of seed at the expense of the lint, but if the pounds of lint per acre can be maintained the greater the amount of seed the greater will be the profit. Whether or not the weight of seed can safely be increased without a decrease in the yield of lint is a matter which has received almost no attention, but which is a promising field for the investigator.

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 Texas Sta. Rpt. 1889.

¹ Georgia Sta. Bul. 20.

CULTURE OF COTTON.

By HARRY HAMMOND.

GEOGRAPHY OF THE COTTON BELT.

The cotton belt covers 24° of longitude and 10° of latitude. Excluding from the count the greater part of Virginia, more than 100,000 square miles of western Texas, and the whole of Kentucky, Kansas, Missouri, Utah, California, Arizona, and New Mexico, in all of which cotton has been cultivated and where a larger demand might cause its culture to be extended, the cotton-growing region measures nearly 600,000 square miles, almost one-third of the total area of settlement, in 1890, of the United States. The 20,000,000 acres planted in cotton occupies barely 5 acres in every 100 of this extensive region. Scarcely 50 per cent of this territory is in farms, and not more than one-fifth has at any time been tilled. This section contained in 1890 a population of over 8,000,000 whites and something over 5,000,000 negroes, in all 13,651,006, every 100 of them producing 53 bales of cotton, an average of 254 pounds of lint per capita.

The Mississippi River, turned from its southeasterly course to one south of west by the bluff lands of Tennessee, Mississippi, and Louisiana, divides the cotton belt into two nearly equal eastern and western portions. Bordering the west of the flood plain of the great river are the oak and hickory uplands of Arkansas, Louisiana, and Texas, stretching westward more than 200 miles to the black Cretaceous prairies of Texas. These black prairies descend from Indian Territory in a broad crescent, its concave edge facing west and inclosing the more elevated red-loam prairies until it thins out into the coast prairies of the southwest in the neighborhood of Austin. To the north the oak and hickory is bounded by the red lands of Arkansas. The counterparts of these regions are found east of the Mississippi. Moving east from the bluff and yellow-loam table-lands that rise from the flood plain of the river, we again meet the oak and hickory lands in Mississippi and Alabama. Beyond these another crescent of black Cretaceous prairies, its concave edge, however, facing east, reaches from northwestern Mississippi to southeastern Alabama. Northeast from the concave border of these prairies lie the valley lands of Alabama, Georgia, and Tennessee, the Coal Measures of those States, the gravelly hills of Alabama, and the central basin of Tennessee. Near the termination of these prairies in southeastern Alabama another region is encountered.

This is a prolongation of the Alleghanies, and passes from the locality named, in a broad belt, to the northeast, across the States of Alabama, Georgia, South Carolina and North Carolina. It is known as the metamorphic or Piedmont region, or, in popular parlance, as the region of granitic rocks. On the northeastern border of this region, in North Carolina, the pine hills are met. The pine-hills region reaches southwestward along the southern border of the Piedmont region and the Alabama and Mississippi prairies, traversing all the Atlantic and Gulf States, interrupted only by the delta of the Mississippi, until it crosses Louisiana and reaches the oak and hickory of Texas. South of the pine-hills region is a broad belt of level pine lands, coextensive with it and everywhere touching either the Atlantic or the Gulf coasts, until it reaches the coast prairies of Louisiana and Texas, where it terminates.

In 1801 South Carolina led the other States in the production of cotton. In 1850 Alabama stood first in the amount produced. Mississippi led in 1860-1880, and Texas stood first in this respect in 1890.

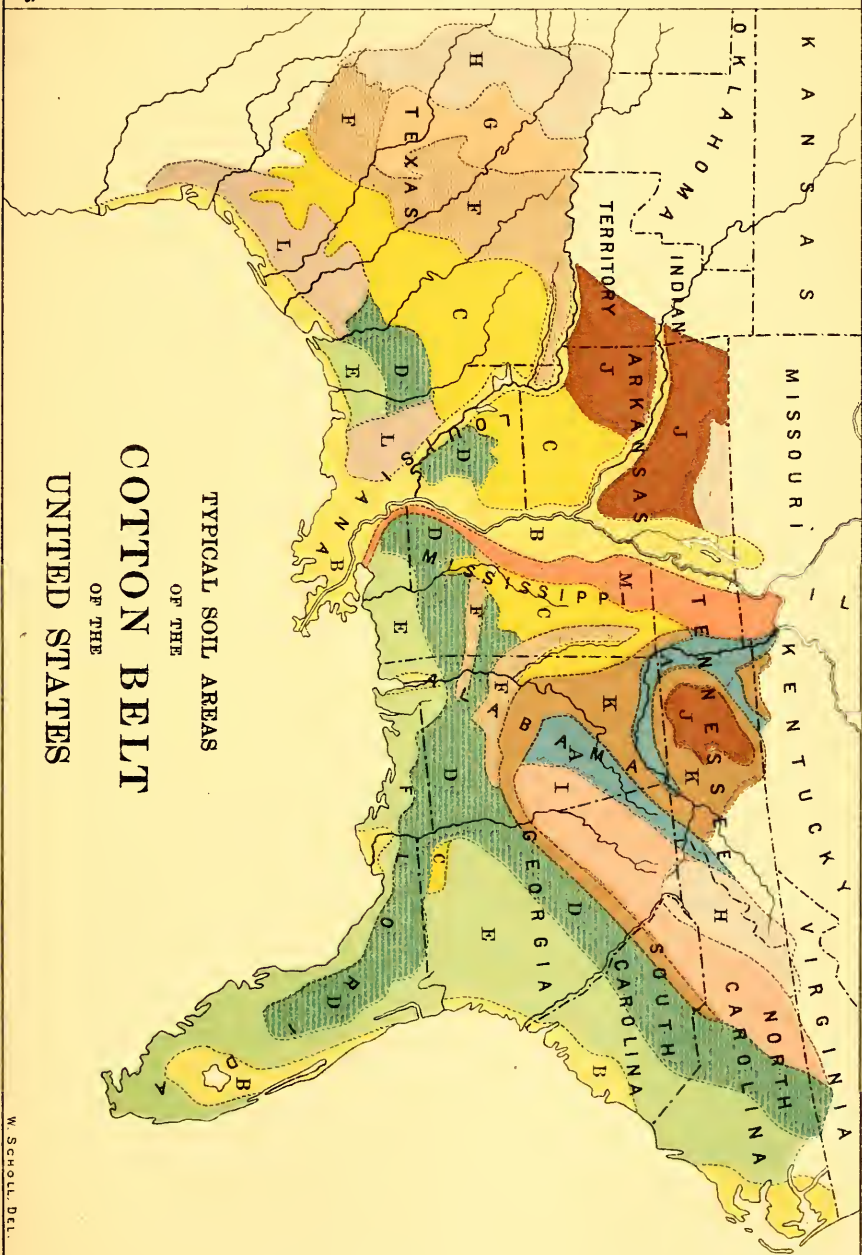
CENTERS OF COTTON PRODUCTION.

The center of cotton production, the point where the weight of all the cotton produced in the various regions of the cotton belt would stand in equilibrium, was located in 1850 a few miles north of Montgomery, Ala. In 1860 this center had moved 200 miles west to a point some 20 miles northeast from Jackson, Miss. Its movement in 1870 was northeast to a point near Carthage, Leake County, Miss. It again moved northeastward into Noxubee County, Miss., in 1880. Its movement was about 60 miles northwest in 1890 to Kosciusko, in Attala County, in the same State. It is probable that since that date the increasing crops of Arkansas, northern Texas, and Indian Territory have drawn the center of cotton production still farther to the northwest.

THE PINE LEVELS.

These extend inland from the Atlantic and Gulf coasts for from 50 to 150 miles and reach an elevation of some 200 feet above sea level, embracing an area of 34,000,000 acres. Forty-four per cent of this area is in farms. Eight per cent was improved land in 1890, being an increase from 6 per cent in 1880. Only 1 per cent of these lands was planted in cotton in 1880, but double that amount was put in in 1890. They produced 2.6 and 3.2 per cent of the total cotton crop at the beginning and close of the eleventh decade, respectively. The cotton acreage was increased during this period 57 per cent and the cotton crop 62 per cent. This was of exceptional occurrence, for it almost always happens that an increase in acreage is not accompanied by a proportional increase in the yield. Both these increments were considerably greater than the increase of the population, which was only 22 per cent. Nevertheless, the pine levels are not given as exclusively to cotton growing as most of

A	VALLEY LANDS
B	ALLUVIAL
C	OAK
D	PINE HILLS
E	PINE FLATS
F	BLACK PRAIRIE
G	RED LOAM PRAIRIE
H	ALPINE & BORDER
I	PIEDMONT
J	RED LANDS
K	SAND HILLS
L	COAST & GREY SILT PRAIRIE
M	BLUFF & CORN HILLS



the cotton belt is; for while the average product per capita of the cotton belt was 231 pounds of lint cotton in 1880 and 259 in 1890, only 85 pounds of lint per capita was produced in 1880 by the inhabitants of the pine levels, increasing in 1890 to 99 pounds. This was not due to lack of fertility in the soil, for the product per acre was equal to, and in instances greater, than some of the other cotton regions, and it only required in 1890 two-tenths of an acre more than the average of the cotton belt to produce a bale of cotton here, which, considering the very easy tillage of these light sandy loams in comparison with most others, did not appreciably increase the cost of production. The yield was a bale to 3.1 acres in 1880 and a bale to 2.9 acres in 1890.

A white population preponderates in 61 of the 89 counties constituting this region. The only State in which the negro population is in excess is South Carolina, where they were settled long ago upon the fertile rice fields and the sea islands, producing long-staple silk cotton. The colored population was only 19 per cent of the population in this region in 1880 and 25 per cent in 1890. That 75 per cent of the population here is white is an observation running counter to the generally received opinion that the moist, warm climate of the low latitudes is unfavorable to the white man, and that nature intended them for the black race. An observation of a similar character in regard to the work animals employed in agriculture will have to be changed. The mule has been thought especially fitted for work in low latitudes, and the South generally has maintained this barren stock at heavy cost. Here, in the lowest latitude, the number of horses exceeds that of mules in 76 out of the 89 counties in the pine levels and coast region, even where the colored race preponderates, they being supposed to prefer the mule.

The farms here are larger than anywhere else in the cotton belt, averaging 233 acres to the farm in 1880, and 190 acres in 1890, against a general average for the cotton belt of 119 acres to the farm. Sixty-nine per cent of these farms are occupied and worked by their owners, only 31 per cent being rented, in which regard this region again offers a striking contrast to the remainder of the cotton belt.

The tillage of these lands is easy. The average is 37 acres of improved land to the work animal as against 22 for the whole cotton belt. Three bales for each work animal is the average, which is also high, the average for the cotton belt being 2.1 bales.

The great agricultural need of the pine levels is drainage, and this, under the increasing subdivisions of the farms, has not received proper attention, and in fact it has not been practicable to drain the land properly. Owing to their immense areas of swamp land, their rich vegetable mold, resting on marl or phosphate rock, has remained untouched. The general culture of cotton is otherwise essentially the same as that to be described in the pine-hills region. There are, however, two notable exceptions—the culture of Sea Island cotton in

South Carolina and Georgia, and of the same cotton in the interior of Georgia—which should have special mention.

Culture of Sea Island cotton.—On the sea islands of South Carolina field labor is performed almost exclusively by negroes. Nearly all of them are engaged in farming on their own account; a large number own farms; a still larger number rent lands for cultivation, and even the laborers are paid most generally by granting them the use of so many acres of land for certain stipulated services. The largest number of acres of Sea Island cotton planted under one management scarcely anywhere exceeds 100 acres. The white planters do not average probably more than 30 acres, and this requires that they should be landlords of considerable estates; for, as the laborers are frequently given 5 to 7 acres for two days' work in the week, and as two days' work per week does not suffice for the cultivation of more than 4 acres, to cultivate 30 acres of cotton under this system requires in addition 75 acres of land; add to this the amount usually planted in corn and other crops, and we will have 120 acres. As, under the best system, the land lies fallow every other year, the planter of 30 acres of cotton will require 240 acres of open land; and as scarcely one-fifth of the land is under cultivation, such a planter will probably own 1,200 acres. This state of things is owing to the scarcity of capital, and to the low price of land and labor.

Drainage, although said by Governor Seabrooke to be so little attended to, has of necessity always been practiced to some extent on the sea islands. The remarkably high beds on which the cotton is planted here—18 inches to 2 feet high—subserve this purpose. The best planters have long had open drains in their fields. These were generally made by running two furrows with a plow and afterwards hauling the loose dirt out with a hoe, thus leaving an open ditch, if it may be so termed, a foot or more in depth. In recent years the farmers of James Island have made deeper ditches and placed plank drains in them. Seeing the great benefit resulting from this, they subsequently replaced the plank with regular drainage tile. The outlets open on the sea at the low-water mark, and the pressure of the water on the pipes preserves a constant outflow, even at high tide. In this manner, land only 1 or 2 feet above high water is susceptible of thorough drainage to the depth of 4 and even of 5 feet. The borders of these islands being usually the highest part and the richest land in the interior often much lower, a wide field for improvement is offered in this direction.

In the early part of the century, when agriculture had so far developed the value of these lands as to make \$60 an acre a not unusual price, the use of the plow was entirely unknown here and all the operations of tillage were performed by hand with the hoe alone. This continued to be the usual practice until 1865. Since then plows have come more and more into use, until their employment became quite general.

Fallowing is practiced to the extent that land planted in cotton one

year is pastured the next by cattle and sheep but not by hogs, and it is claimed that great benefit is derived by having the loose soil of these islands thus trodden by stock during the year they lie fallow. The rapid growth of bushes, briars, and weeds is kept down by the stock, and the large growth of cotton stalks of the previous year, after furnishing food for the animals, is broken up and scattered. If care be taken "that the grass is not eaten so close as to expose the soil on the top of the beds to the summer sun," it is found when the stock is turned off in November to range through the cultivated fields that the pasture "is in exactly the right condition for the coming season's cotton fields, with no cotton stalks or troublesome growth to be got off or under the land and make it too husky."

A mule can do the plowing required in the cultivation of 30 acres of Sea Island cotton, and can, in addition, cultivate a sufficiency of land to supply corn for its own feed. The first step in the preparation of the land is to hoe off the weeds ("hurricane"), cut up the cotton stalks, and pile and burn this litter. This costs 40 cents an acre. Bushes are grubbed up at 7 cents an acre. The land is not thoroughly plowed, but in February two furrows are run with a single-horse turning plow in the middles between the old beds, leaving a trench 7 or 8 inches deep. In this furrow a subsoil plow may or may not be run, according to the character of the soil—whether wet or dry. On James Island, where underdrainage is practiced, this furrow is generally used. Before plows came into use this trench was never made, and even now it is omitted by some of the most successful planters. In this trench, or in the middle of the alley when no trench is made, the manure is placed. This consists usually of 20 cart loads of marsh mud and 1,000 to 1,400 pounds of cotton seed to the acre. Stable and lot manure, together with compost of marsh mud, are also applied at the rate of 40 cart loads to the acre on such portion of the land as the limited number of stock belonging to the farmer enables him to treat in this manner. On the lines of manure thus laid down a certain quantity of commercial fertilizers is drilled. This practice, formerly unknown, is very common now, even the smallest negro farmers often going heavily in debt to obtain these fertilizers. The land is now ready for listing, which is done by hauling the soil from the top and sides of the old beds onto the manure with a hoe. A more recent practice is to lap in with two furrows of a turning plow on the manure. This last costs only $17\frac{1}{2}$ cents per acre, while the listing with the hoe costs 80 cents, although the latter has the advantage of bringing all the humus and vegetable mold directly to the spot where the roots of the plant are to grow. Over the mass of dirt, weeds, manure, etc., thus collected in the old alley a double roller 5 feet from center to center and weighing about 800 pounds is passed to press together and compact the whole, completing two rows at a time. All this should be finished by the first to the middle of March, and the bed is then built up by lapping in two more furrows on a side with a single or double horse turning plow.

The land is now ready for planting, which may begin any time after March 20, but April 1 to 10 is the time preferred. Cotton planters are not generally used. Three laborers do this work; the one ahead chops a hole with a hoe, on the top of the bed, at intervals of 12 to 18 inches; another drops eight or ten seed in each hole, and a third follows and covers carefully with the hoe. Three to four pecks of seed are used to the acre. The seed makes its appearance above ground in eight to twelve days after it is planted, and the stand is perfected from the second week in April to the first week in May. Hoeing begins about the first of May. The second hoeing takes place the last of May. The plows then break out the middles (the spaces between the new beds where the old beds stood). The hoe hands follow and pull up the loose dirt left by the plows to the foot of the cotton. This is called "hauling," and by it the new bed is completed, the cotton is kept from "flagging" (falling down), and the grass is kept under. It costs 80 cents an acre. At the second hoeing some stalks are thinned from the bunch in which the seed breaks the ground, and at each succeeding hoeing and hauling other stalks are removed until in July only one stalk of each bunch is left. There are four hoeings and four haulings, one or more furrows with a sweep being run through the middles previous to each hauling. By the last of July the culture is completed, except to run a furrow between the rows in August to destroy the grass and keep the cotton growing.

The first blossoms appear about the middle of June, when the cotton is 15 inches high, and the bolls open in August, when the plants have attained a growth of 4 to 5 feet. Cotton picking commences from the last week in August to the first week in September. By the 15th of December the crop is gathered.

When the cotton has been picked, weighed, and housed, it is next spread out in the sun on what is called an "arbor." This is a platform 25 feet or more square made usually of inch boards. Here the sun and air dry the cotton, preventing it from heating, which it is liable to do when stored in bulk, and, it is also thought, causes the lint to absorb some of the oil in the seed, which adds to the silky luster of the fiber. After being thus dried, it may be either stored or passed at once to the whipper, a machine that knocks the dust and sand out and leaves the cotton whiter and more open. Formerly it was all assorted. A hand was given 150 pounds of seed cotton as a day's task, which he thoroughly overhauled, picking out all specks, stained cotton, fragments of leaf, etc. At present, however, this is usually done by two hands, who examine the cotton as it passes to the gin, and two others behind the gin, who pick out cracked seed, motes, etc., as the lint issues from the gin. The roller gin in some form has always been and still is used for detaching the lint from this black seed cotton.

The first successful crop of Sea Island cotton was grown by William Elliott on Hilton Head in 1790. In 1805 this quality of cotton sold for 30 cents per pound, while uplands were selling at 22 cents; in 1816 at

47 cents, with uplands at 27 cents. The crop of 1825 amounted to 26,039 bales, of which 7,779 were grown in Georgia, and the balance in South Carolina. In that year Mr. Kinsey Burden, of South Carolina, sold 60 bales at \$1.10 per pound. The same gentleman sold his crop of another year for \$1.25 per pound, when the average price of uplands was 9½ cents. He also sold two bales in 1828 at \$2 a pound, which is the highest price on record. The crop of Sea Island rose to 36,776 bales in 1829, of which 13,729 were made in Georgia, and the remainder on the sea islands of South Carolina. The crop fell off in 1839, South Carolina still leading with 9,975 bales, and Georgia making 4,225. The two States together made 20,484 bales in 1849, South Carolina making 18,924. During the fifties this culture was extended to Florida, and that State produced nearly 11,000 bales in 1856. In 1859 Florida led with a crop of 20,353 bales, while South Carolina made 13,391 and Georgia 10,352. The Sea Island crop exceeded 26,000 bales in 1869 and in 1879, in both years Florida producing a larger crop. In 1870 Texas contributed 704 bales of Sea Island cotton, and in 1871 made 1,100 bales; since that date the crop there has gradually dwindled down and there is no record of it after 1882-83. In 1889 the crop reached 46,841 bales, Florida producing 25,111 bales, Georgia 12,431 bales, and South Carolina 9,299. It was about this date that this culture began to develop among the small farmers of the pine levels at a considerable distance inland from the sea. So successful has this adventure proved that in 1894 the Sea Island crop of Georgia rose to 39,367 bales, while that of Florida fell to 19,107, and South Carolina, where this culture had originated and flourished longest, fell back to a crop of 2,578. It had seemed for many years that islands on the South Carolina coast possessed a natural monopoly for the production of the finest staple. At that time the culture was conducted under the superintendence of men of high intelligence, and the selection of the seed and the cultivation and preparation of the crop for market was attended to with great skill and the most scrupulous care. At present it is chiefly in the hands of small farmers of the colored race, whose intelligence, skill, and care are wholly occupied in securing a bare subsistence for themselves. It is doubtful if there is any local monopoly of the production of long-staple cotton. It has been grown successfully in the up country, more than 100 miles from the coast, and all the seed from which the finest strains of Sea Island cotton have been derived came from seed planted in the interior of South Carolina, for several years, during the late war. The extent to which the manufacture of these long staples in the United States has increased in recent years is noteworthy: In 1870 only 5 per cent of the crop was consumed in this country; by 1880 the consumption had risen to 35 per cent; and in 1894, although the crop had increased 130 per cent, nearly 40 per cent of it was consumed at home. In addition to that, a very large amount of long-staple cotton—perhaps more than 10,000 bales—was imported from Egypt for manufacture.

The Egyptian cotton is inferior to the finest grades of Carolina Sea Island, and it is also inferior to the Santee and Florida, the growth of which has so greatly increased of late years. It competes with the long-staple uplands, the cultivation of which was very profitable some years since, but which have been almost entirely abandoned owing to being supplanted by imports from Egypt.

The culture of Sea Island cotton in the interior of Georgia is not so elaborate as the method described as pursued on the coast. Seed is brought every year from the coast in quantities to plant patches sufficient to furnish seed for the whole crop the ensuing year. The seed of the second season is thought to do better, but after that the staple deteriorates and seed is used which has been planted away from the coast only one year. They use a very effective homemade implement for cutting down the old stalks. It is a roller on which iron blades are fastened longitudinally. Shafts are attached and it is drawn by one horse along one row at a time, cutting the stalks into lengths of 8 to 10 inches. The general culture resembles that of upland cotton, and is usually performed entirely by the farmer and his family. They raise their own supplies and provisions to sell, such as poultry, eggs, honey, and country-cured hams. Elsewhere the falling off in the long-staple crops of the coast and Florida indicates a depression as great, or greater, in this culture as in any other branch of agriculture.

The average value of farm lands in the pine levels is lower than elsewhere in the cotton belt, but it rose during the eleventh decade from \$2.09 to \$4.01 per acre, while unimproved land may be bought for 50 cents an acre.

Five per cent of these lands in North Carolina are said to produce three-fourths of a bale to the acre without fertilizers, 20 per cent half a bale, and 50 per cent one-third of a bale. Five estimates of the cost of production there in 1880 ranged from 5½ cents per pound of lint to 10 cents, the average being 7.3 cents. Wharton gives the cost of the crop of 1891 as 7½ cents and of 1892 as 11 cents, owing to unfavorable seasons, and the average for three years as 8 cents. The crop of Mr. Nobles cost 7 cents in 1892 and 5½ cents in 1893, the reduced cost resulting from diminishing the acreage and planting other crops.

In South Carolina the cost of growing Sea Island cotton was estimated in 1880 at from 15 cents to 21 cents per pound of lint, with a net profit per acre of \$38 to \$78 at the prices then prevailing. The cost of producing short staples in the interior was placed then at 6½ cents; estimates in 1893 give the cost of short staple at 5 cents on the best and 10 to 14 cents per pound on the poorest land.

In Georgia the cost of producing short staple in the pine levels was estimated in 1880 at 8 cents to 10 cents per pound; in 1892 it is placed at 7½ cents. The cost of growing Sea Island cotton was thought to be 50 cents a pound in 1880.

In the Alabama pine levels about 1 per cent of the land produces,

without fertilizers, a bale to the acre, at a cost of 3 cents a pound; 2 per cent, three-fourths of a bale, costing 3.4 cents; 15 per cent, half a bale, costing 4 cents; 30 per cent produces one-third of a bale, costing 5.8 cents.

On the pine levels of Mississippi in 1880 cotton seems to have been produced cheaper than anywhere else in the State, the lowest estimate for the whole State, as to cost of production—4 cents—being given there. In 1893 the estimate of cost of production is 4 cents on the best land and 6½ cents on the poorer lands.

THE PINE-HILLS REGION.

This region stretches inland from the northern border of the pine levels along the whole extent of the latter, reaching an elevation of 200 to 400 feet above sea level. The country is rolling, and the open pine woods of the pine levels is replaced by a long-leaf pine woods, with an undergrowth of many varieties of oak, and some hickory. This region covers over 39,000,000 acres, 58 per cent of which is in farms. Twenty-two per cent of the whole area consists of improved land, and 7 per cent of it was planted in cotton in 1890. It produced in 1890 15 per cent of the whole cotton crop, the acreage having been increased 34 per cent, and the crop 37 per cent, during the eleventh decade.

The increase in acreage was general except in the long-leaf pine hills of Texas, where a slight falling off was shown. It was greatest in South Carolina, amounting there to 64 per cent. The increase in the crop was not so uniform. There was an actual decrease in North Carolina, notwithstanding the increased acreage, as well as in Texas. In South Carolina the increased acreage produced a larger crop by only 57 per cent, but in Georgia, Alabama, Mississippi, and Louisiana, the crops were increased very considerably more than the acreage.

This region contains Burke, the county of largest cotton production in Georgia; Mecklenburg, the banner cotton county of North Carolina, and Barbour, second in production among the counties of Alabama. The credit, however, of producing more cotton in 1890 than any other county in this region belongs to Barnwell, in South Carolina, which grew 50,170 bales, placing it fourth in the list of cotton-producing counties in the cotton belt for that year, the others being Abbeville, S. C., and Washington and Bolivar counties, Miss.

The population did not increase so rapidly as the acreage and crop of cotton, being only 16 per cent greater in 1890 than it was in 1880. Although the white population preponderates in 63 per cent of the counties constituting this region, being more numerous than the colored race in North Carolina, Alabama, Mississippi, Louisiana, and Texas, nevertheless the pine hills of South Carolina and Georgia are so thickly settled with negroes that it made this race count for 51 per cent of the whole population of the region in 1890. The colored race was 53 per cent of the population in 1880. The per capita production

of cotton amounted to 275 pounds of lint at the beginning and 337 pounds of lint at the close of the eleventh decade.

The work animals are mostly mules, especially in Georgia and South Carolina, where there are large colored populations; in Mississippi, Louisiana, and Texas, where the whites preponderate, there are more horses. The acreage of improved land per work animal is 33 acres, an increase of 3 acres during the eleventh decade. This acreage is greatest in North and South Carolina (40 and 37 acres, respectively) than it is in Louisiana (19 acres) and in Texas (6 acres). Four and one-tenth bales of cotton were produced to the work animal in 1890, against 3.7 bales in 1880. In South Carolina 6.4 bales were made, in Georgia 6.1, and in Alabama 4.8, and less in the other States, until Texas only produced 0.9 of a bale. But everywhere with the increase of arable land to the work animal there was also an increase in the cotton produced to the animal.

The average size of the farms in the pine hills in 1890 was 134 acres, being a decrease of 27 acres to the farm since the census of 1880. Forty-three per cent of these farms were under 50 acres, an increase in the number of farms of this class of 3 per cent during the decade. During this period there was a decline in the number of farms worked by owners of 5 per cent, only 53 per cent belonging to that class. There was no increase in the number of farms rented for a share of the crop, and the larger number which were rented were rented for fixed money rents.

Marlboro County, in South Carolina, is a typical cotton county of this region. It produced in 1890 32,306 bales of cotton on 58,836 acres, being a little over a bale to 1.8 acres, a yield not exceeded anywhere except in the alluvium of the Mississippi River.

The prevailing tendency of agriculture in the cotton belt may be illustrated by the changes in the expenditure of agricultural energy that have taken place in Marlboro in the last fifty years, exhibited by the per capita production of the leading staples of the farm, as follows:

Production of crops and farm stock per capita in Marlboro County, S. C.

Year.	Cotton (lint).	Cereals.	Horses and mules.	Neat cattle.	Swine.	Sheep.
	<i>Pounds.</i>	<i>Bushels.</i>				
1840.....	71	36	0.20	1.10	1.90	0.34
1860.....	437	29	.20	.66	1.68	.28
1890.....	647	21	.16	.11	.39	.01

The change has been continuous and progressive from a more or less mixed husbandry to one which has made everything subsidiary to the production of cotton. The lands of Marlboro were thought to be exhausted in the early part of this century, and numbers of the population emigrated to the fresh lands of Alabama. The lands they left were level and wet. An extensive system of drainage was instituted, and in the course of forty years it is thought that the general water

level has been lowered 5 feet. This was the foundation on which they built.

From one-third in some parts to two-thirds in others of the field work was done by whites in 1880, notwithstanding that the colored population has largely increased since the improvement in the cotton crop, their services being in requisition for picking that crop. The size of the farms is larger than in the other counties of this region in South Carolina, and the occupancy by owners is greater. Very little of the land lies fallow. Cropping is continuous. Fields planted in cotton for fourteen successive years produce better than they did at first. Rotation of crops when practiced is similar to what it is elsewhere—cotton one year, corn the next, followed by oats in the fall, the oats followed the ensuing summer by corn and peas, or by peas alone. The fourth year the stubble is broken up, 8 to 10 inches deep, and cotton planted again. The culture of very little land has been abandoned of late. Within the eleventh decade the improved land has been increased 27 per cent, and the estimated value of farms 74 per cent.

Green manuring with the cowpea sown broadcast has been extensively practiced, and when cotton is laid by, peas are often drilled between the rows, where the beds for the next year's cotton crop is to be thrown up. All of the cotton seed, or its equivalent in meal, is returned to the soil, either alone or composted with stable manure, woods mold, and superphosphate of lime. In 1880 an average of \$4.77 per acre for each acre in cotton was expended in commercial fertilizers. After clearing the old stalks, or breaking the stubble land, a furrow with a shovel plow was run in the old alley, or the land broken broadcast was laid off in 4-foot rows with the same implement. The cotton-seed compost and stable manure were placed in this furrow and the bed built upon it with single-horse turn plows. This should be done early in February to prevent the cotton seed from sprouting and coming up. Another point is to get the manure covered as deeply as practicable, so as to keep it moist. Even after the greatest care, the farmer is often disappointed to find his manure brought to the surface during cultivation, where, exposed to the dry heat of summer, it is of no avail. It appears that the particles of the soil are not at rest, but under various influences, especially rains, they cave in and settle. The law of specific gravity operates, and in time the diverse components are assorted and find their respective levels as surely as cork floats or lead sinks in water.

Planting takes place in April, usually with a seed sower. Early planting is best, except for the risk of damage by frost, for late planting may lack moisture to come up to a stand. The after culture is with the hoe, to keep the cotton clean in the drill. This is most easily done in fields planted continuously in cotton, because the long summer cultivation, especially if done thoroughly late in the season, is very effective in destroying the seeds of every variety of grass and weeds. Each

hoeing is followed by the plow, which throws the dirt close up to the stalk. The cultivation of cotton throughout the pine hills does not vary much from this. In some places the labor of knocking down the cotton stalks with a club or pulling them is avoided by using a stalk cutter. The usual form is a gum log 18 inches in diameter and 6 feet long set to roll in a frame, to which a tongue for two horses is fitted. Bars of iron 3 inches by $\frac{1}{2}$ inch, sharpened on one edge, are fastened edgewise by staples to the log. A man and two horses will cut up the stalks on 10 to 12 acres a day with this implement, taking two rows at a time.

Before the profuse use of commercial fertilizers was depended on so largely, the cotton growers considered it of extreme importance to have the plants exactly spaced, so that each might obtain its share of what the unaided soil had to offer. This was effected in various ways. A man was furnished with a dibble to make holes, in which he dropped the seed, covering them with his foot. A pointer extending from the dibble marked the spot where each successive hole was to be made. Another arrangement was to drag the beds off, two at a time, with a drag pulled by a horse walking in the alley. This left a fresh surface free of grass. The drag was followed by a horse pulling two wheels, on which cogs, spaced at the desired distances, made the holes for the seed in the two rows that had been dragged off. The dibble was followed by four women or children, who dropped the seed in the holes, and the operation was completed by covering a single row with a scraper pushed by hand, or two by a board drawn by a horse. Nearly perfect stands were obtained and kept by this precision, for there could never be any doubt when a hill was missing or was cut up by the hoe hand, and careful replanting was required. There were 210 hills to the acre row, 60 rows to the acre; and if the stalks bore 6 bolls on the average, half a bale was made to the acre, a fair and pretty certain average for land without commercial fertilizers, depending for restoration on rest each alternate year and such stable manure as could be obtained. Now 6 bolls to the stalk would be a failure, for the spacing of the hills being left entirely to the judgment of the hoe hand, they stand anywhere from 1 to 3 feet apart, the deficiency in their number being corrected by the application of commercial fertilizers until it has become an axiom that cotton will produce equally well when planted 3 by 3 feet, or 4 by 4 feet, or 4 by 1 foot.

Shallow culture has always been aimed at in the light, loamy soil of the pine hills.

Notwithstanding more or less depressing reports, owing to the increase of the population and to the increments in repairs and improvements which convert the daily labor of the farmer into the fixed capital of the country, farm values have risen in the pine hills region during the eleventh decade 42 per cent. The largest increase (152 per cent) took place in Louisiana and the least (24 per cent) in North Carolina. The

other States stood in the following order: Alabama, 70 per cent; South Carolina, 61; Mississippi, 59; Texas, 30, and Georgia, 29 per cent. The increase in the value of agricultural products for the whole region was 22 per cent, ranging from an increase of 98 per cent in Louisiana to a decrease of 17 per cent in the pine hills of North Carolina. The other States stood in the following order: Alabama, Mississippi, Georgia, South Carolina, Texas. The average value per acre of farm lands was \$6.18 in 1890, an increase from \$4.54 in 1880. These values were greater in the eastern and older States, and less in the western and younger ones, ranging from \$9.30 in South Carolina to \$3.45 in Texas. The values for the other States stood: North Carolina, \$7.44; Georgia, \$5.93; Alabama, \$4.31; Mississippi, \$4.74; Louisiana, \$3.92.

The estimates of the cost of production were as follows: North Carolina in 1880, three estimates, varying from $5\frac{1}{2}$ to 10 cents, average 7 cents; in 1892, labor, provisions, and rent being cheap, the estimate was $3\frac{3}{4}$ cents on the best land, and 6.6 cents on land making 200 pounds of lint to the acre, which itself was a good deal above the average product of the region. South Carolina, eleven estimates, in 1880, ranging from 6 to $10\frac{3}{4}$ cents, placed the average cost at 8 cents per pound; in 1892, five estimates, running from $5\frac{1}{2}$ to $7\frac{3}{4}$ cents, gives an average of 6.63 cents per pound. Georgia estimates for 1880 place the cost at 3 to 6 cents, under good management, with all necessary supplies. Alabama, 1880, estimates 8 cents; 1892, cost $4\frac{5}{7}$ cents (exclusive of rent) and $7\frac{3}{4}$ cents. Mississippi, 1892, cost $6\frac{1}{4}$ cents. These estimates, with one exception in Alabama, include charges for interest on plant, rent, and management, and would therefore indicate a fair profit.

METAMORPHIC OR PIEDMONT REGION.

The northern border of the pine-hills region touches a region extending through North Carolina, South Carolina, Georgia, and Alabama, underlain by granite and kindred rocks, known as the metamorphic or Piedmont region. The southern limits of this region are marked by the falls of the rivers which, rising in the lofty Appalachian range that walls in its northern borders, pass through it on a steep incline and leave it here for a quieter channel through the sands and alluvium of the lower country. The whole of this region is not planted in cotton. Two mountainous counties of northern Georgia produce none; in six counties in western North Carolina 2,000 acres only were planted in it, while ten other counties there produce no cotton at all. The area of this region included in the cotton belt proper contains 32,000,000 acres, and produced in 1890 16.8 per cent of the entire crop. Only 10 per cent of this area was planted in cotton, being an increase of 2 per cent since 1880. Thirty-five per cent of the region is improved land and 80 per cent is in farms, being in both these regards a larger percentage than elsewhere in the cotton belt. Of the improved lands 30 per cent was in cotton in 1890, being 3 per cent more than in 1880. The acreage

in cotton rose during the eleventh decade from something over 2,500,000 acres to nearly 3,500,000. The percentage of increase was greatest in South Carolina (35 per cent) and least in Alabama (20 per cent). The 400,000 additional acres in Georgia were only 29 per cent increase on what was in cotton there in 1880. The increase in North Carolina was 31 per cent, but it was accompanied by a decrease of 7 per cent of the crop. During the same period the crop of this region was increased 32 per cent. The increase of the crop, except in North Carolina, was general. Georgia showed an increase of 42 per cent, Alabama of 40, and South Carolina of 35. The number of acres required to make a bale remained very much the same. The average was 2.8 acres, Georgia alone showing greater production, making a bale to 2.7 acres, while it required 3 acres to do this in 1880. The per capita production of cotton also showed an increase, being 269 pounds of lint for each head of the population in 1890 against 228 pounds in 1880.

The white population preponderates, only 42 per cent belonging to the colored race, a decrease of 1 per cent during the eleventh decade. The decrease was marked in South Carolina, Georgia, and Alabama, and was accompanied in each of these States by an increase in the per capita production of cotton. There was an increase of the colored population in North Carolina, and there a marked decrease in the per capita production of cotton is to be observed.

In 1890 the 220,000 farms of the Piedmont region averaged 114 acres to the farm, a decrease in size from 131 acres in 1880. Only half of these farms were occupied by owners at the later date, while more than half (55 per cent) were so occupied in 1880. The percentage of small farms under 50 acres had also increased from 36 per cent to 40 per cent of the whole number. The larger porportion of renters paid a share of the crop, 38 per cent of the farms being rented on this condition and 12 per cent for a fixed money rent. In South Carolina and Georgia, where the colored populations were the largest, the greater percentages of rented farms and small farms were found, and the decrease in the average acreage of farms was greatest. The reverse of this was true of North Carolina and Alabama, where the proportion of the colored population was less. In the same connection it may be noted that mules far outnumbered the horses in South Carolina and Georgia and the horses outnumbered the mules in North Carolina and Alabama. The average of improved land to the work animal increased during the eleventh decade from 29 to 34 acres, and was general throughout this region. Three and seven-tenths bales of cotton were produced to the work animal in 1890, an increase of 0.7 of a bale over 1880. In South Carolina 5.5 bales to the work animal were made; in Georgia, 5.2; in Alabama, 4.3.

Cotton culture in the South has not yet reached that stage of development where everyone has settled down on the best plan. Diversity of methods and of implements will be noticed on adjacent farms.

Nevertheless, there is almost always some model system which is followed more or less closely and with greater or less success. In the Piedmont region Mr. David Dickson, of Sparta, Ga., a very successful cotton grower and forcible writer on agriculture, set an example which has been very widely followed. He advocated deep breaking and subsoiling, saying that to stand a two weeks' drought a cotton plant must have 4 inches depth of soil and 6 inches depth of subsoil well broken, and for every additional week an inch more of soil, with the same subsoiling. He did not recommend fall breaking, for the winters being usually mild and wet, plowed land was exposed to injury from washing and leaching, and was apt to run together closer than if it had not been broken. In cold, dry winters the reverse is true, but these are of rare occurrence in this latitude. The land should be broken as near the time for planting as practicable. Commence at the foot of the hill and circle round on a level, finishing at the top. Rotation of crops was rest, cotton, corn, small grain, and rest again. Rows are laid off 4 feet apart with a shovel plow, running twice in the furrow and leaving it 8 inches deep. Into this furrow drill the fertilizer and manure, running a scooter plow 5 inches wide on each side to cover it. Build up the bed by running a turning plow, going 7 inches deep on each side of the scooter furrows and throwing the dirt over them. The bed is completed with a large 2-horse shovel running in the middle and bursting it out. Seed is drilled in with a planter. As soon as the plants are well up they are sided with a 22-inch sweep, running flat so as not to throw dirt, and then hoed, not chopped but scraped, the hoe never being raised more than 18 inches from the ground. The plants are left two or three together the width of the hoe apart, it being desirable to have eight stalks to the yard. Cotton thick in the row with good distance between the rows fruits earlier and better. The wing of the sweep should be turned up for the next plowing and a little dirt thrown to the cotton. The sweeps should be kept constantly sharpened, and should never run deeper than one-half to 1 inch. Two hoeings and ten furrows with the sweep, eight to side the cotton and two to split out the middle of the row, complete the working. This makes $1\frac{1}{4}$ days' work of a mule to the acre, going 16.6 miles a day. In picking, hands were trained to pull out all the cotton from the boll at one movement of the hand. Pickers trained in this way gathered two to three bales a week for Mr. Dickson. He commenced using fertilizer in 1846, and was the first farmer in Georgia to do so, and his success induced many others to make enormous expenditures on this account. He did not think homemade manure any cheaper than commercial fertilizers, although he recommended its saving and use. It must be said that very few farmers get through their crops with two hoeings; four are more frequently required. Crab grass, which pervades the whole cotton belt, is easily killed when young, but when it forms a stool and tillers not only is its growth rapid but its vitality is greatly augmented. "Crab" is a corruption of "crap,"

which is in turn the corrupted pronunciation of "crop" in some rural dialects. De Brahm, writing in 1752, says of it:

New land produces scarcely any grass, and one hoeing will do for the season, but the grass comes and increases in such a manner that sometimes three hoeings are scarcely sufficient in one season, and when this comes to be the case the planters relinquish these fields for pastures and clear new ground of its wood.

It is on account of this grass, also, that most farmers prefer to hoe before plowing, to make sure of cleaning the drill of this fine grass, which is likely to escape notice if the dirt has been moved by the plow, so that until a shower has settled the dirt after plowing the drill can not be thoroughly cleaned by the hoe. The hoe also necessarily removes some dirt from the plant and should be followed by the plow to return it. Few farmers are able to plow only one-half inch, or even 1 inch deep, as Mr. Dickson did, although it would be very desirable to do so. If carefully measured, the depth of the cultivating furrow will be found to exceed 2 inches more frequently than it falls below it.

The counties leading in cotton production are Mecklenburg, N. C.; Abbeville, S. C. (which stood third among the counties of the cotton belt in the annual production in 1890); Coweta, Ga., and Chambers, Ala. The value per acre of lands in farms increased during the eleventh decade from \$6.07 per acre to \$8.42. It stood as follows in the different States: North Carolina, \$6.75 to \$8.70; South Carolina, \$5.91 to \$8.75; Georgia, \$6.01 to \$8.38; Alabama, \$4.17 to \$5.43.

The cost of producing a pound of cotton lint in the Piedmont region is stated as follows: North Carolina, 1880, four estimates, varying from 4.6 to 10 cents, average 6.2 cents; 1892, six estimates, varying from 5 to 8 cents, average 6.3 cents; South Carolina, eight estimates in 1880, varying from 5.71 to 8.25 cents, average 6.91 cents; 1893, eight estimates, from 5 to 8 cents, average 5.7 cents; Georgia, 1893, six estimates, varying from $5\frac{3}{4}$ to $8\frac{1}{4}$ cents, average 6.76 cents; Alabama, 1893, one estimate, 8 cents, which is the same as the cost given by Professor Smith for the whole State in 1880.

SAND-HILLS REGION.

The Piedmont region only touches the pine hills at certain points. Between them lies a belt of sand hills 500 to 800 feet in height, being often higher than the Piedmont counties immediately north of them. The sand-hills region extends through North Carolina, South Carolina, and Georgia. On reaching Alabama it passes between the Piedmont region and the black prairies, and, circling northwestward around the Coal Measures, spreads out in Tennessee and Kentucky. The total area is 6,000,000 acres, 66 per cent of which is in farms and 5 per cent in cotton. It produces about one-tenth as much cotton as the Piedmont region, or 1.6 per cent of the total crop. During the eleventh decade the acreage in cotton increased 30 per cent and the crop 28 per cent. This was much more than the increase in the population, which was

only 17 per cent. Sixty-five per cent of the population is white, and here, as in other places where this occurs, it is found that horses are more used than mules; that a larger number of farms are occupied by owners; that the small farms are fewer, and that the size of farms (150 acres) is larger. Nevertheless, in most of these respects farming in the sand hills is changing in accordance with the general changes that are taking place in the cotton belt; farms are decreasing in size, small farms under 50 acres are increasing, owners occupy a smaller percentage, and a greater number are being rented.

The culture of cotton here resembles that of the adjacent regions, except that up to this date larger food and forage supplies and more stock have been raised here.

THE PRAIRIE REGION.

This region of the cotton belt includes the black prairies of Alabama, Mississippi, and Texas, the coast prairies of Louisiana and Texas, the gray-silt prairie of Arkansas, and the red-loam prairie of western Texas. The Texas prairies farther west, being sparsely settled, produce little cotton. The region thus indicated covers more than 65,000,000 acres, of which only 44 per cent in 1880 and 55 per cent in 1890 was in farms. The percentage of improved land rose from 12 to 27 per cent during the eleventh decade and the percentage in cotton from 4 to 6 per cent. In 1880 the prairies produced 16.3 per cent of the whole cotton crop; in 1890 they produced 20.6 per cent. The acreage in cotton had increased 48 per cent and the product 68 per cent, while the population had only increased 23 per cent, the per capita production of cotton rising from 277 pounds of lint to 381 pounds. The largest percentage of total area in farms was in the older States of Alabama (72 per cent) and Mississippi (74 per cent), and the smallest in the coast prairies of Texas west of the Brazos (24 per cent). The percentage of increase in the farm area was greatest in the red-loam prairies of western Texas (160 per cent), and there was a slight decrease in the prairies of northeastern Mississippi, at the other extreme of this region. These red-loam prairies produced only 10,000 bales in 1880, and it was thought that cotton culture had at last reached its western limit here, but the returns of 1890 showed an increase to 74,000 bales, and the limits of cotton culture were moved still farther westward over a wide extent of country, which produced, however, only 6,000 bales in 1890. The most notable increase in the area in farms took place in the central black prairies of Texas (35 per cent), for it was accompanied by a doubling of the area in cotton and an increase of 146 per cent in the cotton produced, the 249,000 bales made there in 1880 being increased to more than 600,000 bales in 1890. When it is remembered that only 7 per cent of the area of these black prairies in Texas is in cotton, against 18 per cent in the black prairies of the older eastern State of Alabama, an idea may be formed of the extent to which the production of cotton

might be developed. There is good reason to believe that the 21,000,000 acres of the central black prairie of Texas could, if need be, produce the entire crop now grown in the South.

Dallas County, Ala., stands first among the cotton-producing counties in the prairies of that State, with a crop of 42,000 bales in 1890; but this was far below the crop produced as far back as 1860, which was over 63,000 bales. So, too, Hinds County, Miss., led the prairie counties there, with a crop of 42,000 bales in 1890, which again fell short of the crop of 54,000 bales which it produced in 1860. Ellis County, Tex., which made only 2,000 bales in 1860, led the black prairie counties of that State in 1890 with a crop of 42,000 bales; in 1892 it made a crop of 50,000 bales, and in 1894 more than 59,000 bales were shipped from Waxahachie, the county seat, and the best estimates place the crop of the county for that year at 100,000 bales. This gives it the distinction of leading all the other counties of the cotton belt in the amount of cotton produced.

In 1880 40 per cent of the population of the prairies was colored; in 1890 the percentage had fallen to 39. It stood, in Alabama, 78 per cent; in Mississippi, 51 per cent; in Louisiana, 44 per cent; in Arkansas, 37 per cent; in Texas, 18 per cent.

The following table shows the figures given in the Eleventh United States Census in regard to land tenures in the prairie region, and also the size of farms, motive power in agriculture, value of farms per acre, and the acres required to make a bale:

Statistics of cotton culture in the prairie region of the cotton belt.

Locality.	Per cent of farms occupied by owners.	Per cent of farms rented.	Average acreage of farms.	Farms of 50 acres and under.	Number of counties in which white or colored and horses or mules, outnumbered.				Value per acre of land in farms.	Acres in cotton to make a bale.	
					White.	Colored.	Horses.	Mules.			
I.											
Black prairie, Texas	54	46	173	31	39	0	39	0	\$12.19	2.4	
Gray-silt prairie, Arkansas.....	61	39	118	36	3	0	3	0	11.83	2.3	
Red-loam prairie, Texas.....	71	29	401	16	15	0	15	0	5.33	2.3	
Coast prairies, Texas.....	63	37	220	43	20	2	22	2	9.82	2.4	
Coast prairies, Louisiana.....	73	27	120	42	4	1	5	0	11.83	2.6	
II.											
Black prairie, Alabama.....	22	78	98	62	0	12	0	12	6.40	3.0	
Black prairie, Mississippi	45	55	119	51	3	4	5	2	5.37	2.7	
Northeast prairie, Mississippi.....	38	62	102	49	2	7	3	6	7.79	4.4	

These facts point in one direction, and the general conclusions are that where the owners of farms largely occupy them (1) the white population generally predominate; (2) horse power is used in preference to mule power; (3) farms have a larger acreage; (4) farms under 50 acres—that is, small farms—are fewer; (5) fewer farms are rented;

(6) the value per acre of land is greater; (7) the production of cotton per acre is greater. Where fewer owners occupy their farms, the facts are the reverse of these several statements.

The lower value of land in the red-loam prairie of western Texas apparently forms an exception to these conclusions. When it is pointed out that this is a sparsely peopled country, newly settled, it ceases to be an exception. The farm acreage, too, on the gray-silt prairies is 1 acre less than the highest acreage in the second series. The explanation of this, if any is needed, is that these light soils have been less attractive to capital than the rich alluvium to be found in nearly every county of well-watered Arkansas; that they tally so well with the more fertile sections tends to confirm the general conclusions. In making this collocation of facts it is not meant to emphasize any one as the only cause of all the others. They go together, and it may be safely said that the difference in cotton production and in the value of farms does not result from any natural conditions, such as greater or less fertility of the soil or a more or less favorable climate. The facts already given as to the cotton production of the leading cotton counties of Alabama and Mississippi in 1860, when agriculture was less advanced, show that in natural fertility they were not inferior to the black prairies of Texas, now the most productive in the prairie region.¹ If they have become so since it must result from the methods pursued by the men who cultivate them, either from choice or the force of circumstances.

The changes which occurred in the rural economy of the prairies during the eleventh decade were similar to those taking place throughout the cotton belt. The number of farms occupied by their owners decreased; the number of small farms increased and the average size of farms diminished; the amount of improved land to the work animal increased, and the percentage of the colored population was less. The increase in the acreage of cotton was accompanied by a very much greater increase in the crop, which was a marked exception to the general rule.

The number and variety of implements recently introduced in cotton culture here, especially in the prairies of Texas, is very much greater than elsewhere in the cotton belt. The planting year commences there December 1—a month or more earlier than in the East—and a good deal of work is done before January 1. If all the cotton has been picked, the first operation is to dispose of the cotton stalks. This is usually done with a stalk chopper. A number of patented implements are used for this purpose. They consist of five to seven steel knives over 2 feet in length, bolted to iron arms which revolve in a frame swung from another frame supported on two wheels. Two horses pull this machine along the cotton row, and the stalks are chopped off by the revolving knives 2 to 4 inches above the ground and cut into pieces.

¹Tenth Census of the United States, 1880, Vols. V and VI. Cotton Production, Parts I and II. (See also chapter on climatology and soils.)

A driver rides, and adds his weight to the blow of the knives. Sometimes a double stalk chopper is used, which takes two rows at a time, and is pulled by three horses, thus saving one hand and a horse. The work is very thorough. Cornstalks are removed by running a heavy roller along the rows, breaking them down, when they are raked by a very large wooden rake, pulled by horses, at right angles to the direction in which the roller moved, piling them in windrows, to be burned. With both these implements a seat is arranged for the driver, and he rides. Breaking, and, in fact, almost all the work of tillage and cultivation, is done with two horses. Several varieties of steel plows with steel beams are used. A large disk plow is being introduced. It consists of one to four heavy steel disks revolving in a heavy frame. Four to eight horses are required to pull it, and it breaks from 2 to 7 acres of the tough prairie land to the depth of 8 inches in a day. Often, however, the preparation for planting cotton consists only in throwing two 2-horse turning-plow furrows into the old alley and completing the preparation by running a large 2-horse double-mold plow in the last year's bed, making in all only three furrows to the row. It is thought best to do this work early, so as to allow time for the beds to settle, which are sometimes freshened up by running a cut-away harrow across them just before planting. A number of excellent cotton-seed planters are used, and they are implements of much greater precision than the Dow-Law planter and its modifications, used in the East, and their cost is proportionally greater. The object aimed at is to deposit the seed regularly in a single line, with barely a space between each, which, while it saves seed, obviates their coming up in bunches, difficult to thin, and lifting the earth and thus exposing the tender stems to the vicissitudes of the spring weather. Practically no fertilizers are used, and very little of the manure from the many thousands of bees fattened here yearly on cotton-seed meal and hulls is utilized. Some farmers say that manures cause the crop to fire in dry seasons, and that the natural fertility of the soil suffices, lands that have been planted successively for forty years producing better than when fresh. There is no doubt that these stiff soils are pulverized and rendered lighter and more productive by some years of tillage, but the old farmers admit that the effect of continued cropping is beginning to show in a somewhat diminished yield in places. Riding 2-horse cultivators have been used for many years. Before their use cotton rows were made 4 feet apart. Since their introduction it has been found that these cultivators clean the rows best when they are spaced 40 inches, and that is now the most common width. Various shares, to suit the circumstances of the case, are used with these cultivators. The first workings, which are deepest, are given with 6-inch sweeps, afterwards 12-inch sweeps are used, and later sometimes even larger ones. The culture is tolerably flat. The double shovel is sometimes used, and it is almost the only 1-horse implement used on most of the

black Texas lands. Some farmers say they would not know how to hitch up a 1-horse team, so little are they used. It is calculated that these sulky cultivators should plow 10 acres a day, but in practice they rarely do more than 7. Two to three hand hoeings are given, and plowing, under the best culture, is done six to seven times in the season, more to stir the surface than to kill grass and weeds. Grass is not so troublesome here in favorable seasons (moderately dry) as elsewhere. Coco, or nut grass, is not much feared, but there is great apprehension regarding Johnson grass. On some farms where it appears it is fenced off to prevent its spreading and treated with heavy doses of arsenic, which kills the land as well as the grass. This would seem hardly necessary, as this grass is readily subdued in the East by close pasturing with stock, and the prairies of Texas themselves furnish an object lesson of the eradication of the native perennial grasses by continuous grazing. All the lands in Texas are fenced in with wire, woodland as well as that under cultivation, and cattle and horses everywhere feed on the stubble after the crops have been gathered.

Picking cotton is a heavy item of expense, the usual price being 50 cents per hundredweight of seed cotton. Cotton pickers here are more expert than elsewhere; children 6 years old sometimes pick 100 pounds, and girls of 9 years have picked as much as 200 pounds. First-class pickers average 500 to 600 pounds a day, and as much as 800 pounds occasionally. A white hand was timed in 1894 and picked 60 pounds in an hour, or a pound a minute. Such results require a very abundant blow of cotton, and the picking is not very neat, a good deal of trash, such as the hulls of bolls and stems, being mixed with the cotton. A variety of "storm proof" cotton so called because it is not easily blown out by winds, is preferred. Nevertheless, in 1895, it was not unusual to see as much as 200 to 300 pounds to the acre of the crop of the previous year fallen out on the ground. A good deal of the crop, also, was left unpicked, not only where the crop was heavy, but almost in the same proportion on the poorer lands. The explanation given was that the tenant farmers did not think it would pay, at the prevailing low prices, to pick, gin, and pack what was in the field for their share—three-fourths of it—and so preferred to send their children to school, with which no doubt the children heartily agreed, for picking cotton in cool weather is not attractive work, being an exercise too light to keep the blood warm. Cotton is not infrequently left in piles in the field after being picked, a practice long abandoned elsewhere, but less ruinous here on account of the dryness of the climate. It is more usual to see a white, canvas-covered wagon left in the field, its pole elevated, to which steelyards are suspended for weighing the cotton, which is afterwards loaded into the wagon and left there until it is hauled to the gin. It is not feared that the cotton thus exposed will be stolen, which is quite different from the case in other States, where it has been found necessary to pass stringent laws punishing the pilfering of seed cotton.

There is very little storage for cotton in Texas. When it is not carried immediately from the gin to the compress and loaded at once on platform cars for transport, the bales are placed on edge in open fields, protected only by a wire fence, and exposed to rain, wind, and dust.

The wastefulness of cotton culture is great in Texas, owing to the great abundance of the staple. There seems to be a waste in horsepower, such small areas being tilled to the horse, and also in wages paid to labor, which have ranged from \$16 to \$18 a month, with shelter, fuel, and rations; fully double what they are in the East. It was common to give \$16 a month for ten months and \$18 a month for the two months during the picking season. Owing to the low prices a reduction is being made to \$10 for ten months and \$20 for the months at picking. The fact is, very little labor is hired in Texas. By far the larger portion of the land is rented out for money rent or worked on shares, the latter being done to a much greater extent than is exhibited by the census returns.

The estimates of the cost of production in 1880 were as follows: Mississippi, 1 estimate, 11 cents per pound of lint; Arkansas, 10 estimates, varying from 3 to 8½ cents, average 6.2 cents; Texas, black prairie, 14 estimates, 3½ to 9½ cents, average 5.3 cents, coast prairies, 7 estimates, from 4½ to 9½ cents, average 6½ cents, red loam prairie, 2 estimates, each 4½ cents. Notice is again directed to the fact that where a country plants only a limited area in cotton, although that country is apparently less favorable for this crop than other more fertile localities, nevertheless the estimates of cost from the limited area are almost always the lowest—an indication that were this culture restricted everywhere to narrower limits cotton might be grown everywhere at a much lower cost.

In 1891 circulars were sent from the agricultural experiment station in Texas requesting the leading farmers in various parts of the State to keep accounts of the actual cost of cotton production in 1892 and furnish the figures to the station. All replies not supported by actual results were discarded. The replies from seven careful, practical cotton growers are summarized in the table below, Nos. 1 to 7. The officers of the station undertook themselves to obtain the same information on the State's farms, and these results are summarized in Nos. 8 to 12. In the statements marked *f* fertilizers were used; in the others the results were obtained from the natural fertility of the soil. In only one instance (No. 2) was any charge for management entered. No. 6 is reported by Jeff Wellborn, who gathered the crop of 1,500 pounds of seed cotton from the acre with a cotton picker at a cost of 10 cents per hundredweight. Figures marked with an asterisk (*) indicate loss. Where the price of the seed is not credited it is because they were exchanged to pay for the ginning and packing. The price of seed in 1892 was \$6.50 per ton and in 1894 it was \$6, but this difference is not charged in the tables. The first section of the table shows the actual

cost of the crop, value of product, and profit for 1892. The second section gives the data of 1892 estimated at the average price ($4\frac{1}{4}$ cents) the crop would have brought in 1894.

Cost of cotton production.

Number.	1892.					1894.			
	Cost of cultivating 1 acre in cotton.	Lint cotton produced.	Value of seed.	Price per pound of lint.	Profit per acre.	Value of lint and seed.	Profit and loss.	Rent.	Proceeds per acre, rent deducted.
		<i>Pounds.</i>		<i>Cents.</i>					
1 <i>f</i>	\$30.55	650	\$4.00	9	\$31.95	\$31.63	\$1.08	\$4.00	\$5.08
2.....	22.32	418	3.00	8 $\frac{1}{2}$	16.18	20.77	*1.55	3.00	1.45
3.....	13.68	250	.....	8 $\frac{1}{2}$	7.57	10.62	*3.06	3.50	.44
4.....	14.71	250	1.00	7	4.39	12.22	*2.40	3.96	1.47
5.....	21.31	426	.....	7 $\frac{1}{2}$	10.64	18.00	*3.30	7.98	4.68
6.....	13.85	500	3.25	7	24.40	24.50	10.65	4.00	14.65
7.....	14.15	250	.....	8 $\frac{1}{2}$	7.10	10.62	*3.53	3.50	*.03
8 <i>f</i>	34.90	544	3.50	9	20.96	26.62	*8.28	3.00	*5.23
9 <i>f</i>	29.36	484	3.12	9	20.34	23.69	*5.67	3.00	*2.67
10 <i>f</i>	27.17	423	2.71	9	16.25	20.69	*6.48	3.00	*3.48
11 <i>f</i>	31.23	502	3.22	9	20.00	24.56	*6.67	3.00	*3.67
12.....	18.84	283	1.82	9	9.21	13.85	*4.99	3.00	*1.99
Average.....	22.62	415	.....	.....	15.77	.....	*2.85	3.73	.89

Excluding No. 6 on account of the very exceptional method by which the cost of picking was reduced, the average cost of production varies from 4.6 to 6.4 cents.

These were good crops, making the unusual average of 415 pounds of lint per acre. At the prices of 1892 they showed an average profit of \$15.77 per acre. The same crops made at the same cost would have shown an average loss per acre at the prices ($4\frac{1}{4}$ cents) of 1894 of \$2.85. The rents were \$3.73 per acre in 1892, and if they are omitted from the charges against the crop in 1894 the cotton growers would have had a surplus above actual expenses of 88 cents an acre. No charge for management was made in any statement except No. 7. The profit in 1892 was large—larger perhaps, than any profit from any staple cultivated on so extensive a scale. Adding in the rent, there is a clear surplus of \$19.50 an acre. Counting the land, buildings, fences, stock, implements, and working capital at \$195 per acre, it was paying 10 per cent (the legal rate of interest in Texas) upon them. Taking the average of the black prairies of Texas, the investment could not have exceeded \$31; double that, on the assumption that these were choice lands, and still the profit was over 30 per cent.

The commissioner of agriculture of Texas in his report for 1892 states that with a population of 2,500,000 and 250,844 farms there were only 57,042 farm laborers working for wages, which explains the high wages paid for farm labor, the average being \$13.89 per month. If each of these farms averaged three cotton pickers and they should only pick 100 pounds each a day, it would amount to 50,000 bales daily, or in the 100 days of a short picking season 5,000,000 bales could be gathered if the labor were effectively distributed.

OAK AND HICKORY REGION.

This region lies on the eastern border of the black prairies of Texas. It extends over eastern Texas and northwestern Louisiana, and southeastern Arkansas to the Mississippi swamps. Its counterpart in the east reaches westward from the northern portion of the black prairies of Alabama and Mississippi to the table-lands and bluff region that rise from the swamps of the Mississippi River. Four counties in western Alabama and three in northeastern Mississippi, just east of the black prairies, are included in this region. It covers nearly 43,000,000 acres, about half of it lying in eastern Texas, and in 1890 it produced 14.4 per cent of the entire crop, and in 1880 it produced a fraction of a per cent less. In 1890 52 per cent of this area was included in farms (over 129,000 in number), and 21 per cent either had been or was under cultivation, nearly 4,000,000 acres of fresh land being brought in during the eleventh decade. This increase was naturally greater in the newer Western States than in the older Eastern ones, rising from 31 per cent in Alabama to 129 per cent in Louisiana. This region reported in 1880 a large amount of land turned out of cultivation, which is included as improved land in the returns of 1890. Such abandoned fields were reported as 20 to 90 per cent of the lands once under cultivation in Mississippi, as 15 to 30 in Arkansas, as 10 to 50 in Louisiana, and as 1 to 50 in Texas. The growth of oak, hickory, and short-leaf pine furnishing material for an extensive lumber business, is evidence of the original good quality of these soils, which immigration has passed over in its movement westward. The area planted in cotton was 7 per cent of the entire area and 32 per cent of the improved land, and increased 45 per cent during the eleventh decade, while the cotton crop only increased 30 per cent. The percentage of increase of acreage in cotton and the percentage of increase of the crop stood as follows in the different States: Alabama, increase of acreage 29 per cent, increase of crop 27 per cent; Mississippi, increase of acreage 14 per cent, increase of crop 12 per cent; Louisiana, increase of acreage 56 per cent, increase of crop 32 per cent; Texas, increase of acreage 52 per cent, increase of crop 44 per cent; Arkansas, increase of acreage 50 per cent, increase of crop 15 per cent—everywhere the same story, so often repeated, that an increase of acreage is not accompanied by a proportional increase of crop, but inevitably by such an increase as reduces the price of the product in a ratio quite as large as that of the increased cost in cultivating the larger area. Within the last thirty years marked changes have occurred in the localities producing the largest amounts of cotton. In Texas in 1860 San Augustine County produced 31,000 bales, which was not only more than any other county in the oak and hickory region, but more, also, than any other county in the State; but in 1890 this county produced only 4,000 bales. The attraction of the western prairies, and the fact that the county lies off the lines of railroad

communication, in part account for this, but this being a well-wooded section lumbering has temporarily diverted attention from agriculture. Bossier Parish, in Louisiana, led the parishes of the region in 1860 with 40,000 bales, but produced only 29,000 in 1890. Pickens County, Ala., led in that State with 29,000 bales in 1860, which were reduced to 18,000 in 1890. Kemper was the leading county of the region in Mississippi, with a crop of 15,000 bales in 1860, which fell to 14,000 in 1890. Arkansas alone is an exception; Jefferson County made 28,000 bales in 1860, and increased the crop to 47,000 in 1890.

During the eleventh decade the product per acre decreased in this region, and it required 2.8 acres at the close of the period to make a bale which had been done on 2.5 acres at the beginning. This decrease in the yield per acre was general. There was also a small decrease in the product of lint per capita of the population, which stood in 1880 at 358 pounds and in 1890 at 351 pounds.

There was an increase in the population of 38 per cent, which, while it was less than the increase in the cotton acreage, was greater than the increase in the cotton crop. Fifty-one per cent of the population was colored in 1890, which was 1 per cent less than in 1880. The highest percentage (55) of colored population was in Louisiana, which showed an increase of 2 per cent during the decade, and the lowest percentage (30) was in Alabama, showing a decrease of 10 per cent since 1880. There was a slight percentage of increase in Arkansas, and a slight decrease in Mississippi and Texas.

The average size of the farms decreased during the eleventh decade from 170 acres to 136 acres. This decrease was general, being greatest in Louisiana, where the size of farms fell from 206 acres to 124 acres, and in Arkansas, where the decrease was from 167 to 141. These two States had an increase in the percentage of colored population. In the other States, which showed a decrease in the percentage of the colored population, the decrease was considerably less. The number of small farms of 50 acres and under increased from 31 to 34 per cent, and the number of farms occupied by owners decreased in a somewhat greater proportion from 67 to 62 per cent. The decrease in the average size of farms, the multiplication of very small farms, and the decrease in the occupancy of farms by their owners, stand parallel to each other, and parallel also to a large extent, but not wholly, with the increase or decrease of the percentage of the colored population in the several localities. The significance of the facts are that the white proprietors are turning over the management of the lands to the small colored farmers, and that "40 acres and a mule" has ceased to be an idle dream of the freedman.

Horses on the farms in this region exceed the mules, the latter outnumbering them in only 8 counties in Louisiana, Mississippi, Arkansas, and Alabama, out of the 89 counties comprising this region. The average number of acres of improved land to the work animal was 23

in 1890, against 16 in 1880; the largest number was 36 acres, in Louisiana, and the smallest 18 acres, in Texas and Louisiana. An average of 2.4 bales was produced to the work animal, ranging from 3.7 bales in Louisiana to 0.9 of a bale in Texas.

There is no regular system of rotation of crops in Texas. Cotton is alternated with corn on fresh land for nine or ten years and then the land is planted continuously in cotton until it ceases to produce 600 or 700 pounds of seed cotton to the acre, when it is abandoned and fresh land planted. On the Arkansas oak lands cotton is not infrequently planted for ten years in succession. Where rotation is practiced cotton is followed by corn and then oats, when peas may be planted or cotton follow on the oat stubble. There is seldom any fall plowing, and the usual practice is, after knocking down the cotton stalks or pulling them up and burning them, to lay off in the middle of the old row, if manure or fertilizer is to be used; if no manure is applied the land is simply bedded up on the old middle. The land being easy of culture for the most part, this is done with a 1-horse plow. Cotton-seed planters have come into very general use since 1880. When the plant appears the rows are barred off with a scrape or turn plow, the cotton chopped out, and the dirt thrown back to it either with a turn or shovel plow and sometimes with a scooter. The subsequent plowings are done, by preference, with sweeps, but in grassy seasons turn plows and shovels are used. Two to three hand hoeings and three to four plowings are required before the crop is laid by, early in August. Deep cultivation is said in Mississippi to prevent the plant from running to weed and to favor fruiting. Close and deep plowing is practiced in Louisiana to effect this. In Texas, root pruning is thought efficacious; it is done by running a deep scooter furrow on one side of the row and after an interval treating the other side in the same manner. Topping, early planting, and rapid cultivation with the plow are recommended everywhere to check growth and cause the plant to fruit. Late cotton is thought more apt to run to weed, and also cotton that is planted close in the drill. It will be seen that all these practices are directly the reverse of what is done in Georgia. In Arkansas, also, it is thought bolling is promoted by planting thick in the drill, and running to weed prevented by shallow cultivation. It would be difficult to reconcile such conflicting methods effecting the same object. What experience has taught, however, is not to be lightly set aside, and there might be risk in denying that root cutting in the lower latitude of Texas did not modify the perennial character of the cotton plant, dwarf its growth, and cause its energies to be thrown more toward bearing fruit; or that this perennial character being already restrained by the climate of the higher latitude of Arkansas, fruiting would follow on a more conservative culture.

The value per acre in farms of these lands rose from \$4.22 in 1880 to to \$5.94 in 1890. This value was greatest in Texas (\$7.07) and least in

Alabama (\$3.63). The average value of all the agricultural products per acre fell from \$10.09 in 1880 to \$7.86 in 1890.

The estimates of the cost of producing a pound of lint cotton in 1880 were: For Arkansas, 9 estimates, ranging from 4 to 9 cents, average 6.22 cents; for Louisiana, 7 estimates, ranging from $4\frac{1}{2}$ to 8 cents, average 6.8 cents; for Mississippi, 1 estimate, $4\frac{1}{2}$ cents; for Texas, 12 estimates, ranging from $3\frac{1}{2}$ to $9\frac{1}{2}$ cents, average 6.1 cents.

The estimates of the cost of producing a pound of lint cotton in the oak and hickory lands in 1893 are: For Louisiana, 6 estimates, varying from 5 to $10\frac{1}{2}$ cents, average 6.4 cents; for Arkansas, 5 estimates, ranging from $5\frac{1}{2}$ to 9 cents, average 7 cents.

BLUFF AND BROWN LOAM TABLE-LANDS.

This region lies east of the flood plain of the Mississippi River and extends eastward to the oak uplands. It reaches from Paducah, on the Ohio River, to Baton Rouge, in Louisiana. This region covers more than 11,000,000 acres and produced in 1890 6.8 per cent of the entire cotton crop, having produced in 1880 10.4 per cent. During this period the cotton acreage increased 21 per cent, very nearly double the rate at which the population had increased, and the crop decreased 13 per cent. The area in farms increased from 74 to 77 per cent, it being the most thickly settled region of the cotton belt, except only the Piedmont. The improved lands increased from 30 to 36 per cent, and the lands in cotton from 10 to 12 per cent of the whole area. The percentage of improved land in cotton (35) was the same as in 1880, but it required 2.9 acres to make a bale, which was made on 2.1 acres in 1880. The largest yield was in Louisiana, where 2.1 acres produced a bale in 1880 and 1.6 in 1890. The cane hills of Mississippi made nearly as much, producing a bale to 1.7 acres in each year. The summit in Tennessee made the lowest yield, 2.3 acres in 1880 and 4.2 acres in 1890 being required to make a bale. The production of cotton per capita was 431 pounds of lint in 1880 and 347 in 1890.

Fifty-two per cent of the population was colored in 1890, the percentage having decreased by 2 since 1880. There was a decrease in the proportion of colored to white in Tennessee and Louisiana and an increase in Mississippi, where it formed 69 per cent of the population.

Horses outnumbered the mules on farms in 38 out of the 76 counties in this region. The general average was 19 acres of improved land to the work animal, ranging from 23 acres on the table-land of Mississippi to 17 on the bluff of Louisiana. Two and three-tenths bales were produced to the work animal in 1890 against 3.2 in 1880. The cane hills in Mississippi produced the most, 5.3 bales to the work animal, and the summit in Tennessee the least, 0.7 bale.

The farms averaged 114 acres in 1880 and fell to 106 acres in 1890. The proportion of small farms remained the same, but the percentage occupied by owners fell from 49 to 46. More were rented for a share of the crop than for a fixed money rental.

Broadcast breaking of the soil is rarely done, except on stubble land or land that has been out of cultivation for some time. After cleaning off the stalks, the fertilizer or stable manure, when any is applied, is put in a shovel furrow in the old alley and bedded on. Cotton is planted in ridges $3\frac{1}{2}$ to 4 feet, according to the strength of the land. Cultivation commences as soon as the plant is fairly up by barring off the bed with a scrape or turn plow and sometimes with a bull tongue. The cotton is then hoed out and the dirt returned to it with a turn plow, shovel, or sweep. Sweeps are used for the later plowings, and the cotton is usually hand hoed before each plowing. The weed grows larger here than in Georgia and the Carolinas and is not so heavily fruited, the seed are large, and the ratio of lint is less. It is said, also, that these seed yield less oil. Under these circumstances the farmers are especially desirous of checking the growth of the plant and inducing it to fruit, particularly in wet seasons. Some admit that there is no remedy for this, but many are persuaded that their methods are successful in attaining this end. One recommends shallow culture, cultivating as much as possible with the hoe, and early laying by. His neighbor is equally sure that deep culture and cutting the roots stops the overgrowth and promotes fruiting. Topping is generally spoken of as good, and stable manure and superphosphate are recommended. One set advise that the dirt be thrown to the plant, and another that it be drawn away. Early planting and early thinning are thought by others to be effective.

The value per acre of land in farms in this region varied in 1890 from \$5.64 in Louisiana to \$10.92 in brown loam of Tennessee. The average for the region was \$9.12 against \$8.16 in 1880.

In 1880 four estimates of the cost of production in Mississippi varied from $5\frac{1}{2}$ to 10 cents and averaged 7.2 cents per pound of lint. The estimates in Tennessee varied from $3\frac{1}{2}$ to 10 cents and averaged $8\frac{1}{2}$ cents.

The estimates of the cost of production in 1893 were, for Louisiana, 6.23 to 7 cents per pound of lint; for Mississippi, from 7 to 10 cents (average, 8.4 cents); for Tennessee, 7 cents.

THE ALLUVIAL REGION.

Extensive areas of alluvial lands occur in every Southern State and in almost every region of every State. For example, in South Carolina there are 400,000 acres of such lands below the falls of the rivers, all of it susceptible of drainage, with much that might be irrigated, while scarcely any of it is now cultivated. In such well-watered States as Arkansas and Louisiana there is scarcely a county in which correspondents do not mention the cultivation of bottom lands; but when the alluvial region of the cotton belt is spoken of it is meant to designate the bottom lands of the Mississippi, the Red, and the Brazos rivers. The region thus located contains very nearly 30,000,000 acres,

only 34 per cent of which is in farms, 12 per cent improved, and 6 per cent in cotton, producing 14.4 per cent of the entire cotton crop in 1890 and 14.6 per cent in 1880. Thirty-five per cent of the improved land is in cotton, and no change in this regard is shown since 1880. The aggregate increase in cotton acreage is large, 61 per cent being added to the acreage of 1880, which was accompanied by an increase of yield of only 29 per cent, something more, however, than the increase of the population, which was 25 per cent, raising the per capita production from 368 pounds of lint in 1880 to 393 pounds in 1890. The average of the whole region was a bale to 1.8 acres, while in 1880 this amount was produced upon 1.4 acres, a decline, but still a yield per acre far ahead of any other region of the cotton belt. The highest average yield in 1890 was in the Louisiana bottoms—a bale to 1.4 acres; and the highest of recent years was on these same bottoms in 1880—a bale to 1.2 acres. The lowest average yield in 1890 was on the alluvium of the Red River—a bale to 2.9 acres—while the same lands produced a bale to 1.8 acres in 1880.

Fifty-one per cent of the population is colored, a decrease here, as in every other region except the oak and hickory, since 1880. It stood then at 57 per cent. The percentage of colored population stood highest in the State of Mississippi, where it had increased from 79 per cent in 1880 to 83 per cent in 1890. It stood lowest in the Brazos and Red river bottoms, declining from 31 per cent in 1880 to 29 per cent in 1890. This should be noted, for some of these lands have the reputation of being the least suitable of all for a white population. Their healthfulness has been very greatly improved on the Brazos by sinking artesian wells. In some places pure water can be obtained at a depth of 300 feet and at a cost of \$75 to the well.

In the swamps of Louisiana, Mississippi, and Arkansas the first settlements were made by wealthy planters with numerous negro slaves, and here the colored populations, remaining where they were planted, on the most fertile soils, preponderate to this day. The later settlements on the alluvium, about Crowleys Ridge in Arkansas, along the Red River in Texas, and in the tide-water alluvium of Louisiana, were made chiefly by whites, and there they outnumber the colored race. As the whites preponderate in the extreme south of this region as well as in the north, and sometimes in the central portions, as in Avoyelles Parish, La., the distribution of the races can not be attributed to climatic causes. There is no foundation for the prevalent belief that heat or moisture or malaria has caused the segregation of the colored population. It was effected solely by economic influences, and has been maintained by a race prejudice which has deterred white immigrants from occupying many of the most fertile sections of the South.

Mules outnumber the horses on farms in the alluvial region, and this is especially true where there are large colored populations as in Mississippi and Louisiana; horses, on the other hand, outnumber the

mules on the alluvium of the St. Francis bottoms in Arkansas and in Texas, where the proportion of colored to white is much less. There were 16 acres of improved land to the work animal in 1890 against 13 in 1880. This increase was general in every section. The largest acreage was in the State of Mississippi (19 acres against 17 in 1880) and the least in the Red River section in Texas (14 acres against 11 in 1880). There was an average of 3.6 bales made to the work animal in each year. In Mississippi and in the alluvial region north of Red River in Louisiana 7.4 bales were made to the work animal, and in the tide-water alluvial region of Louisiana only 1 bale.

The average size of farms decreased from 171 acres in 1880 to 117 acres in 1890. The percentage of farms of 50 acres and less was very considerably increased. At the same time the percentage of farms (as is invariably the case) occupied by owners showed a decrease from 49 to 46 per cent. The increase in the percentage of rented farms was especially noticeable where the colored population preponderated, rising from 48 per cent in 1880 to 72 per cent in Mississippi, but only from 44 to 50 per cent in the Red River section of Texas. There is reason to doubt whether the figures of the Eleventh Census represent the changes of this character existing in 1894. A much larger proportion of the lands must be rented, chiefly for a share of the crop. So little land is worked by hired labor that in some sections managers of large estates have no rate of wages, tenants to the number of several hundred cultivating the land under various modifications of the share system.

Few agricultural regions anywhere present so fine an appearance as these alluvial lands. The traveler may pass for miles through broad, level, neatly cultivated fields, extending on either hand from 1 to 2 miles and walled in by a heavy growth of tall and stately forests. The cotton planters are gone, but the cotton plantations remain with their comfortable quarters, formerly for laborers, now for tenants, so numerous as to have the appearance of a widely scattered, but continuous village. The farmstead in a group of pecan trees, with the manager's neat cottage, the large stables, and the ginhouse fitted with the most modern improvements, have a prosperous look. At rare intervals the handsome residence of the old owner may be seen, but it wears a deserted look, and it is very seldom that either he or his family occupy it, even for a short time. They have moved to the towns, and he has taken up a profession, or become a banker, merchant, cotton factor, or engaged in some other occupation which helps him to support his plantation. There is everywhere a large amount of fresh land cleared. The tenants' rents are remitted for such clearings, which cost the owner little outlay. The broom sedge of the abandoned old fields, so conspicuous a feature in the landscape of the uplands, is no longer seen here. Outside of these clearings, the chief improvements are those which have been made in the levee system of the Mississippi River. Previous to

the year 1859 their construction was chiefly in the hands of local boards of planters, and no decided results were obtained. In 1879 the Mississippi River Commission was organized, and the Congress of the United States appropriated \$4,000,000 for the work. Since that date great progress has been made in the efforts to control the flood waters of the Mississippi, the work being carried on by Congress in conjunction with State and local boards. The latter impose local taxes, usually so much a bale for each bale of cotton raised in the district, and Congress adds a sum equal to the tax raised. Whether this work when completed will fulfill all the expectations that are entertained for it remains to be seen. These lands have been considered inexhaustible in their fertility, but it must be remembered that this fertility has been from time to time renewed by the floods that are being walled out. In other alluvial regions farmers who have dammed out the river freshets have found, after some seasons of cropping, that their lands were becoming less fertile.

There is no regular system of rotation of crops. Land that has been planted in cotton for forty successive years in Bolivar County, Miss., produces just as well the last year as it did the first. Nevertheless, a desultory rotation is sometimes practiced. Cotton is followed by corn, and after corn oats are put in, a crop of peas being taken after the oats, with cotton again the next year. In Louisiana, sugar cane and potatoes are sometimes added to these other crops, but it is seldom that cotton is left out for more than one year. The implements of agriculture used are like everything else here—of the latest and most improved pattern. They are similar to the implements noticed when speaking of the Texas prairies. A new sulky cultivator with disks—three on each side of the row, which it straddles and works at one operation—is being introduced in the place of plows, and much is expected of it. As a rule, the early cultivation is deep. The turn plow or scrape is used to throw the dirt from the cotton, and after it is hoed and thinned to return the dirt to it. There are three to four hand hoeings, and it is plowed as frequently, sweeps and various harrows being used later in the season. Besides the universal crab grass, coco, or nut grass (*Cyperus rotundus*), gives great trouble. After being shaved off with the hoe or plow it resumes its growth immediately, and adds considerably to the cost of culture. Harrowing is thought the most effective means of tearing the roots and nuts, and the effort is made to cover it with dirt from the plow instead of cutting it off, for, in the first case, it is found that leaves rot off before it grows again. The land is generally left clean and nearly level when the crop is laid by. The efforts to promote fruiting and prevent the plant from running to weed are the same as those already noticed—as various and as conflicting. A single subsoil colter furrow run in the middle of the row is the only new suggestion, both sides of the row having been treated in a similar way by others. A few admit that there is no remedy when a warm, wet season supervenes.

The usual wages are 50 cents a day, or 50 cents per hundredweight, for picking cotton. Very few laborers are hired by the month or the year. As has been said, most of the land is rented for money—\$3 to \$5 an acre, formerly for as much as \$10—or is worked on shares of the crop. The laborers are furnished with a house, fuel, and garden, and when the law requires stock to be fenced in a pasture is inclosed for their stock. There is no charge for this, and only such supplies as are advanced are charged. In some sections it is customary to pay \$5 an acre for the area of cotton a hand plants and cultivates up to the time of laying by. Picking is paid for extra, and so is any other work outside of the acres contracted for. The very low prices of the last season have induced employers to discuss the propriety of reducing this wage to \$3.50 an acre. When it is remembered that field work does not commence often until March, that all other work is paid for at the rates of day labor, that unlimited hunting and fishing is allowed, in an excellent game country, and that all the perquisites mentioned are enjoyed by the laborer for an entire year, it does not seem that his lot is a hard one. They look well dressed and well fed, but very few of them have availed themselves of their opportunities to become the owners of land, while the white laborers, who work side by side with them on the same footing—Germans and Italians—find little difficulty in achieving this, even when they have to pay \$30 to \$40 an acre for land. In 1890 Washington County, Miss., produced 87,000 bales of cotton, an amount larger than that produced by any county in the cotton belt at that date. This was at the rate of a bale to 1.4 acres. In the same year Tensas Parish, La., made an average of a bale to 1.1 acres, but the aggregate crop only amounted to 40,000 bales, a great falling off from the crop of 1860, which mounted up to 140,000 bales, a yield not yet equaled anywhere, and shows to a limited extent—for the country was new in 1860—the capacity of those lands for producing cotton on a large scale under thorough management.

The average value per acre of land in farms in this region, as estimated in the last census, was \$14.48, a rise from the estimated value in 1880, which was \$9.70. The increase was greatest in the Red River country of Texas, where the lands rose from \$7 to \$17 an acre.

The cost of production in 1880 per pound of lint was: Mississippi, 28 estimates, varying from 5 to 9 cents, average 7.4 cents; Louisiana, 9 estimates, varying from $5\frac{1}{2}$ to 9 cents, average 7.4 cents; Texas, 5 estimates, varying from $3\frac{1}{2}$ to 7 cents, average 5.2 cents; Arkansas, 7 estimates, varying from 4 to 10 cents, average 7 cents.

The cost of production for 1893 is given as follows: Mississippi, 5 estimates, varying from 6.3 to $11\frac{1}{3}$ cents, average 8.3 cents; 4 estimates, excluding rent, vary from 3.9 to 8.2 cents, average 5.5 cents; Louisiana, 3 statements, from $4\frac{3}{4}$ to $5\frac{3}{4}$ cents, average 4.9 cents; Arkansas, 1 estimate, 4 cents.

RED-LOAM LANDS.

These lands, comprising in all something over 13,000,000 acres and producing 2.6 per cent of the cotton crop in 1890 and a larger percentage (3.3) in 1880, are found east and west of the Mississippi River. The largest section occurs in Arkansas, where they rise in concentric terraces from each bank of the Arkansas River to the height of 2,000 feet above sea level and cover over 10,000,000 acres. The cotton crop there was 196,000 bales in 1890, an increase of 22 per cent on the crop of 1880. It required, however, an increase of 86 per cent in acreage to effect this. One and seven-tenths acres made a bale in 1880, and 2.6 in 1890. The size of the farms remained the same, averaging 105 acres in each year. Only 31 per cent of the farms were under 50 acres, and the number rented was also a good deal below the average, but they increased 7 per cent during the eleventh decade. Only 8 per cent of the population was colored in 1880, but increased during the decade to 13 per cent. The number of horses on farms exceeded that of mules in 20 counties, and the mules outnumbered the horses in 2 other counties.

Ten estimates of the cost in 1880 of producing a pound of lint, varied from 3.45 cents to 8.5 cents; average, 6.19 cents.

The eastern counterpart of the red loam of Arkansas is found in the 2,500,000 acres in the central basin of Tennessee. The cotton crop here fell to 16,504 bales in 1890, from 47,085 bales in 1880, although the acreage only decreased 11 per cent. Ninety-nine per cent of this basin is in farms, a larger proportion than anywhere else in the cotton belt; 61 per cent is in improved land—again a larger proportion than elsewhere in the cotton belt—and only 3.7 per cent of the area was planted in cotton. Another notable exception to the change occurring elsewhere is that here we find the only instance where the farms increased in size. A very slight increase, it is true, only 106 acres in 1890 against 104 in 1880, but in line with the average increase of 3 acres which took place during that period in the size of the farms of the United States at large. The number of farms under 50 acres decreased 14 per cent, which is exceptional also; but the number rented obeyed the general tendency, and showed a small increase. It required 2.4 acres to make a bale in 1880 and 4.2 acres in 1890.

The population was 37 per cent colored in 1880 and fell to 33 per cent in 1890. Horses were more numerous on the farms in 7 counties, and mules in 2.

THE VALLEY REGION.

The Unaka and Cumberland valleys in southeast Tennessee and northwest Georgia, together with the valleys of the Coosa in Alabama and of the Tennessee River in that State and in Tennessee, have been grouped under what is called the valley region, including nearly

15,000,000 acres, much of which is too elevated to be planted in cotton. In 1890 the area in cotton exceeded 795,000 acres, an increase of 41 per cent on the acreage of 1880, showing that cotton growing has made progress in these altitudes, although the product fell 9,000 bales short of what it was in 1880. In that year 4.2 per cent of the entire cotton crop was grown here; ten years later, but 3.1 per cent. In the first year a bale was made to 2.3 acres, and in the last to 3.4 acres. The larger part of the crop is grown in Alabama. This region is too widely scattered and the importance of its various divisions of too little consequence to the production of cotton to justify a detailed mention of them. It is to be noted, however, that some of the very best staples of upland cotton is produced here. Forty bales raised in northwestern Georgia were quoted in New Orleans and also in Boston, in January, 1895, at $3\frac{1}{2}$ and $3\frac{3}{4}$ cents above ordinary uplands of the same grade.

THE ALPINE REGIONS.

These lands are found in North Carolina, South Carolina, Georgia, Tennessee, Arkansas, and Texas, and produce about 0.9 per cent of the entire cotton crop. The conditions of culture are so various as to preclude general description, and they are not of sufficient importance to require a detailed description. Mention of other cotton-growing localities must also be omitted for similar reasons, and have not been included in any of the general statements that have been given. Among these is Florida, where the largest cotton crop ever made was only 65,000 bales, a crop smaller than that of several counties of the cotton belt; Missouri, that one year grew as much as 20,000 bales; Virginia, that never reached that figure; Illinois, that made 1,482 bales in 1860; Kansas, that made 212 bales in 1890; Kentucky, that made its largest crop of 1,367 bales in 1880; Indiana, that made 14 bales in 1850; New Mexico, that made 19 bales in 1860; Utah, that produced 136 bales in the same year; and California, that made 34 bales in 1870. Of very much greater consequence are the cotton crops of Indian Territory and Oklahoma, but data are wanting in regard to them. Estimates of them were included in the returns made for Texas in 1880 and 1890, and it is very probable that they were underestimates. The crop in 1894 was estimated at over 112,000 bales. The number and wide dispersion of these localities show the enormous extension that might be given to cotton growing in the United States if there were a profitable margin between the price and the cost of production.

GENERAL OBSERVATIONS ON COTTON CULTURE.

The matter of the first consideration in the culture of cotton, as in that of any other crop, is to prevent the removal of the soil by washing. Everywhere in the hill country neglect in this regard has resulted in the denudation of the soil from extensive areas of cultivated fields, rendering them barren, and devastating other fields lying at a lower

level. Nor does the injury stop here. The public roads become convenient channels along which, to their destruction, these muddy floods at last pour into the streams, damming them up, causing freshets, and converting fertile bottoms into miasmatic marshes. The evil is generally recognized, and to some, but to a wholly inadequate extent, remedies are applied by terraces and hillside plowing. Where this is thoroughly done, and persisted in, it has proved eminently successful. A very common error has, however, attended the practice. It is that some fall should be given the line of the terrace, to allow the water to escape. The result is, that while one gully may be cured by such a terrace, a larger amount of water is concentrated at its lower terminus, and another and larger gully created there. The terrace should be on an exact level, and must from time to time be amended, on account of changes occurring in the spaces between the terraces. A spirit level may be used to establish the line of terrace, but a simpler, cheaper, and more accurate implement is a compass, made of light stuff, and strengthened with a crossbar. The legs should be 15 feet apart at the ground, coming together 7 feet above it. At the apex a cord is suspended, with a weight attached to act as a plumb bob. When the feet are on a level, the place where the plumb cord crosses the bar is marked. In stepping off the terrace the level will be exact when the plumb line corresponds with the mark on the crossbar. It would seem proper that legislation should compel owners on the higher levels to restrain the rains, which, falling on their fields, issue in destructive floods on their neighbors' at a lower level.¹

DRAINAGE.

The usual substitute for drainage in the cotton field is putting the plants on a high bed and cultivating them deep. It is an expensive substitute, and the rice and sugar planters along the border of the cotton illustrate with ample object lessons the benefits and methods of drainage. The trouble is that the original outlay for drainage is considerable, while the makeshifts, though in the end more costly, are within the reach of the small cultivator. It would seem desirable for the legislature to establish some equitable method of adjusting a right of way for outlet ditches.

INCLOSURES.

Many strong arguments² have been brought against fencing in cultivated fields and allowing stock freedom of range, and many laws modifying the old practice have been passed in recent years. Perhaps nowhere has so radical a change been effected in this regard as in South Carolina, where it is required that stock be kept in fenced inclosures and heavy penalties imposed when they trespass. This law has promoted the cultivation of large areas of land. Since its passage

¹ U. S. Dept. of Agr., Farmers' Bul. No. 20.

² U. S. Dept. of Agr. Rpt. 1871.

2,500,000 acres, or 74 per cent more land, have been brought under cultivation, adding largely to the cotton crop, while the grain crops have increased only half as much. In the face of the increased area under culture, the increased crop, the larger population, and the greater wealth, there has been an absolute decrease of 23 per cent of horned cattle, 26 per cent of hogs, and 33 per cent of sheep. It has assisted in the development of a one-sided husbandry, and to the diminution of agricultural values—the value of land among the others.

SUBSOILING.

Subsoiling and deep breaking are open to question. There is no question that a deep, mellow soil is to be preferred, but the efforts to obtain it are limited by the cost, by the risk of injury to some soils through leaching, and to others by bringing sterile earth to the surface. Sandy soils may suffer in the first way, and heavy clays in the second. Experiments to determine the value of these operations are conflicting and inconclusive.

ROTATION.

Rotation of crops opens a wide field of inquiry. The usual practices have been noticed, and the value of broad-leaved and narrow-leaved plants or root crops and crops maturing above ground in rotations might be mentioned, but there is an absence of exact knowledge here, which is a cause of much distrust. The rotation of growths observed everywhere in nature shows its necessity, but this rotation differs with every slight variation of soil, and nothing is accurately known about it. Such knowledge would have to go far beyond the theory of the exhaustion of certain fertilizing constituents of the soil. It would have to deal with hosts of living animal and vegetable friends and foes who fight for or against each growing crop and render changes necessary.

The farmer's mind grows confused over the complicated conditions of this great struggle, and after vainly attempting to understand and conform to them, he withdraws, turns his fields over to nature, and lets them "rest." And nature, resuming her work of growing heavier and heavier crops every year, restores the fertility which man has destroyed by his exhaustive culture. Even Peter Henderson, the great gardener, said rest was necessary to his gardens once in five years.

Exhaustion of the soil differs in intensity, but for the most part it is only temporary. Fields considered utterly used up and thrown out for years when cultivated again have produced better than those which have been under a management more or less careful. Nevertheless this temporary exhaustion must inevitably occur in every soil not treated to restoratives, notwithstanding that full crops of cotton have been grown on some soils for more than forty successive years.

PLANTING AND CULTIVATION.

Bedding up land previous to planting is universally practiced. Where manures are drilled in, this is indispensable. It forms a warm seed bed in the cool weather of early spring and possesses other advantages. The plants are usually left 2 to 3 inches above the middle of the row, which in 4-foot rows gives a slope of an inch to the foot. This causes the plow in cultivating to lean from the plants, to go deepest in the middle of the row, and, as a consequence, to cut fewer roots.

Four feet is the usually accepted distance between the rows. The distance between the plants seems of little importance within the limits of 8 to 14 inches. Still, as nothing but cotton stalks will make cotton, it is unsafe on average land to risk wider spans than 1 foot. Nothing conclusive has been settled about checked cotton. It may save a hoeing, which should cost about 30 cents an acre, and as plowing is done at about the same cost the question of saving is not determined. The skillful use of the hoe does the most accurate and thorough work. Good crops are made with the hoe without using the plow at all. It may be said that cotton growing was originally established entirely by hoe culture, even the soil for planting being prepared with the hoe.

The perfect cotton planter is not yet invented. It should drop five or six seed in a single line at regular intervals, say a foot apart. In very dry seasons a narrow and deep coulter furrow, the dirt closing in behind it, is run immediately in advance of the planter. It freshens up the bed and assists very much the germination of the seed.

Much is said about deep and shallow culture, and many believe that they can affect the plant beneficially by practicing the one or the other. The only certainty is that all grass and weeds must be vigorously kept down, and that the capillary pores, through which the moisture escapes after rains, must be broken. The first is most thoroughly effected by a broad, sharp sweep, which takes everything it meets, while going shallower than most other plows. Harrows and cultivators are apt to be turned aside by stubborn bunches of grass, which thus escape them. But the sweep does not distribute the loose dirt as generally as a light harrow does and therefore is not as effective in the mulching process. The effect of cutting roots depends entirely upon the season that follows the operation. The following experiments will show how difficult it is to arrive at results in this matter. In the month of June, the cotton plants being 18 inches high, dirt was drawn up 6 inches around some; it was drawn away to the depth of 6 inches from others; the roots of others were cut all round close to the stalk to the depth of 6 inches, and the next stalks had all the roots cut off below 6 inches. These last wilted in a few moments from this heroic treatment, but seemed to recover in a few days. A rainy season ensued, a vigorous growth set in, and when the crop matured no difference could be observed in the fruitfulness of the different series of plants.

The date of cotton planting reaches from March 1 to June 10. Cotton is seldom planted at the latter date, except when put in after a crop of oats. A good crop is made when the season is especially favorable, but the occurrence of drought makes it exceedingly uncertain. The plants also are more liable to the attacks of caterpillars, which only make their appearance in force late in the season. They prefer to feed on the younger and fresher stalks, and it was thought in some sections that the frequent recurrence of the cotton worm was in some degree promoted by the late planting of cotton after oats, which was much in vogue at one time. At least they were not so bad after it was abandoned or before it was commenced. The last regular planting is May 20 under the mountains in Georgia. The following are the dates in the various sections:

Planting commences March 1 in southern Texas; March 15, middle Louisiana, Texas coast; March 20, southern Mississippi; March 25, South Carolina coast, pine hills of South Carolina and Georgia, middle Mississippi; April 1, Mississippi bottoms, middle Texas, southern Arkansas; April 5, northwest Georgia; April 7, middle Arkansas; April 10, west Tennessee, Piedmont, North Carolina, South Carolina, Georgia, upper Alabama, north Arkansas, upper Texas; April 20, northern Louisiana; May 20, northeast Georgia.

The first blooms appear May 15 in southern Texas; May 20, central Louisiana; May 25, central Texas, southwest Georgia; June 1, Mississippi bottoms, southern Arkansas, middle Georgia; June 10, pine hills South Carolina, middle Alabama, central Georgia, Tennessee; June 20, northwest Louisiana, middle Arkansas, northwest Georgia, southern North Carolina; July 4, northern Arkansas, northern Texas; July 10, northeast North Carolina; July 25, northwest Tennessee.

The first bolls open May 15 in southern Texas; June 25, middle Texas; July 1, south Louisiana; July 10, middle Louisiana; July 15, southern Georgia, pine hills South Carolina; August 1, northwest Louisiana, south Arkansas, coast North Carolina; September 1, Piedmont, North Carolina, red-loam prairies Texas; September 15, north Arkansas.

Picking commences July 10 in southern Texas; August 1, southern Louisiana, central Texas; August 15, pine hills South Carolina, coast of Georgia and South Carolina, Mississippi uplands; August 25, northwest Louisiana, Mississippi bottoms; September 1, north Texas, coast of North Carolina, northwest Georgia; October 1, northwest Texas, north Arkansas.

PERIOD OF GROWTH.

The following data relating to the above and other important points in the life of the cotton plant are from records carefully kept in South Carolina, near Augusta, Ga.

Of 100 seed planted, 10 in a hill, March 29, 1887, 24 came up of which 2 died, 39 could not be found and were probably eaten by insects, 23 rotted, and 14 seemed sound but failed to germinate.

The first plant appeared in 14 days after planting; the 10 hills were up to a complete stand in 18 days, and no seed came up after 30 days. This season was cool and wet, but in very dry seasons seed may lie in the ground from April 1 to June 10, and then come up to a good stand. The third leaf made its appearance in 8 days after the plant came up and in 22 days after the seed was planted; the fourth leaf appeared the day following. The significance of this observation is that after the true leaves appear, the plant, being no longer dependent on the seed leaves for its supply of nourishment, is not so liable to injury from cold.

Other series of seed were put in the ground at later dates and the following observations recorded from day to day: The first form (bud) was seen on a plant coming up in April, 41 days after the plant appeared, and 53 days after it was planted. For all the other plants coming up in April, the average was 40 days to the form, ranging from 34 to 45 days, appearing earlier in the warmer weather and later in the cooler weather. For plants coming up in May, the average was 29 days from the appearance of the plant to the first form, ranging from 25 to 39 days, to which 8 days may be added, to show time from planting to forming. Forms appearing in May bloomed in 21 to 32 days, average 25 days; forms appearing in June bloomed in 20 to 27 days, average 24 days; forms appearing in July bloomed in 20 to 26 days, average 24 days; forms appearing in August bloomed in 21 to 27 days, average 25 days. Blooms appearing in June made open bolls in 45 to 56 days, average 52 days; blooms appearing in July made open bolls in 64 to 71 days, average 65 days; blooms appearing in August made open bolls in 46 to 58 days, average 52 days. Forms on May 24 made open bolls August 9; forms on June 24 made open bolls September 21; forms on July 24 made open bolls October 8; forms on August 24 made open bolls November 9. As killing frosts occur about November 17, it would seem that the latest blooms that can be counted on would be about September 1. From this it follows that the minimum period from planting to the first open boll is 120 days, and that the maximum period is 157 days. The interval of 37 days between these periods is more than sufficient to fix a full crop of fruit if the condition of the weather is favorable to the plant at the fruiting stage.

SHEDDING OF FORMS, BLOOMS, AND BOLLS.

When the weather is not favorable at the fruiting stage, the otherwise hardy cotton plant displays its greatest weakness. It sheds its forms, its blooms, and often its half-grown bolls. The following table, condensed from the daily record above referred to, represents to some extent the loss occasioned in this manner. The plants having received very careful attention, the loss exhibited is a good deal below the average sustained in ordinary field culture.

Proportion of forms which produce bolls.

Date of coming up.	Number of plants.	Forms.			Blossoms and bolls dropping.	Bolls maturing.	Per cent maturing.
		Appeared.	Died.	Bloomed.			
April.....	7	1,700	1,231	469	163	306	18
May.....	10	2,586	1,819	667	199	468	18
June.....	2	154	106	48	12	36	23
July.....	1	60	24	36	19	7	11

The 1,580 bolls picked before September 10 weighed 20.5 pounds, or about 77 bolls to the pound; 432 bolls, picked September 19, weighed 5.75 pounds, or 75 bolls to the pound; 293 bolls, picked October 5, weighed 3 pounds, or 97 bolls to the pound; 493 bolls, picked October 24, weighed 3.5 pounds, or 140 bolls to the pound. The average for the whole season was 85 bolls to the pound.

These plants were fertilized at the rate of 936 pounds to the acre, one-fourth acid phosphate and three-fourths cotton-seed meal. They were planted in 4-foot rows, 18 inches between the hills, which would give 9,360 plants to the acre. If an acre had fruited as these 20 plants did, and every form had stuck and matured into an average boll, the yield would have been 25,952 pounds of seed cotton to the acre, a yield undreamed of. As it turned out, they actually produced at the rate of 4,400 pounds to the acre, a yield that has seldom, if ever, been attained. Such calculations show how misleading it is to apply estimates on small patches to field crops, but it also shows that much more might be obtained by greater care and precision.

A more thorough study of the cotton plant might discover means to obviate this great waste. At present cotton growers are at a loss to form a correct idea of the cause or to apply any effectual remedy. A week or two before cotton opens, sometimes a month, the crop being clean, field work stops. Formerly much important work of repairs and improvement was done during this interval. Now the hands that were engaged in cultivating the crop are discharged and no work except what is absolutely indispensable is done.

PICKING.

Cotton picking is the most tedious and expensive operation in cotton growing. The picking of the crop of 1894 is estimated to have cost not less than \$60,000,000. The most of the picking was paid for at 50 cents per hundredweight, and planters in Texas who grew as much as 2,500 bales said it had cost them \$9 a bale to gather their crops. It is very light work, at the most pleasant season of the year, and it is effectively performed by women and even by small children, as well as by men. In the early days of this culture the amounts of cotton picked were small. It is related in the *Southern Cultivator* that the report that a young man had picked 100 pounds in a day created great excitement among the farmers in Georgia, who came from far and near to see it

done and gave a barbecue in honor of the achievement. For a long time this has been a low average for ordinary pickers.

As early as 1839 there is a record of 86 hands—men, women, and children, old and young—averaging over 133 pounds of seed cotton apiece a day. In October, 1894, 10 convicts of the Mississippi penitentiary picked in 5½ days 18,340 pounds of cotton, a daily average of 333 pounds per man. The picking season will average in duration at least 100 days, and picking at the above rate would turn out 22 bales to the hand. It has never been assumed that one man could cultivate more land than would make 10 bales, so that one man is able at average full work to gather as much as two can make. This, however, is very far from being the case, and in the Mississippi bottoms the same year it was not unusual to hear of tenants and space workers who did not gather during the whole season as much as a bale to each picker in their families. Strikes among cotton pickers are not made by combination, but they are executed as effectually and destructively by individuals. It is very difficult to get them to work until the cotton is fully open, and it is hard to stimulate them to pick over 100 pounds a day. The damage resulting from slack work here is often very serious, due in part to the loss of some cotton by falling out, and to an equal extent to the injury to the quality of that which is gathered, the staple being soiled by dust and stained by the coloring matter from the bolls. It has been thought that the production of cotton would be limited by the amount that could be gathered. This limit is still remote. Excluding the population of towns and villages, who do a considerable share in cotton picking, and deducting one-third for children under 11 years of age, there remains an exclusively rural population in the cotton States of over 6,800,000, all more or less occupied in cotton growing and capable, at the low average of 100 pounds a day, of picking daily more than 450,000 bales, or the very large crop of 1894 in 20 or 21 days; and if they did the same task during the whole season they could gather four or five times as much as the largest crop yet made.

Much skill and capital have been expended in efforts to make a machine that would pick cotton. It can not be said that any has proved successful in solving a problem that seems about equal to that of gathering strawberries or raspberries by machinery. This could be done if it were not for the injury to the berries; and if they were to be made into jam, perhaps assorting and washing machines might be invented to utilize a portion of the harvest. Cotton-picking machines gather limbs, leaves, and bolls, and pass the whole through a cleaning separator that, it is claimed, leaves the cotton in the condition of average cotton picked by hand. A cotton-picking machine with a driver and two horses, taking a row at a time, would go over about 6 acres a day. The cost of the work of an expensive and complicated machine, as this must necessarily be, would hardly be less than \$5 a day, and if the cotton were gathered at the right stage there should not be more

than 200 pounds to the acre open. Cotton left in the field for a fuller opening than that is liable to serious damage, and in case of storms to almost total loss. The machine would thus gather at the most 1,200 pounds a day at a cost of 41.6 cents per hundredweight, the present cost being from 40 to 50 cents, and so highly paid at that that there is little doubt it will be reduced to 30 cents or less (as it has been already in some localities), and even then expert pickers will earn from \$1 to \$1.50 a day and more.

In improving short-staple cotton there is a growing tendency to develop varieties which take on and open all their fruit at nearly the same time. If such a variety were perfected, it would simplify the gathering by machinery, especially as such varieties at present shed their leaves about the time the cotton begins to open, thus removing the character of trash which it is more difficult to separate than either the stems or the bolls.

COST OF COTTON PRODUCTION.

The cotton crop that it is possible to grow and gather has been shown to have no practical limits, either in the area of land on which it can be cultivated or in the labor available to gather it. It may be added that one-fifth of the horses and mules at present on farms in the cotton States would suffice to cultivate the largest crop that has ever been put in. More land can always be prepared and planted by a given amount of horsepower than can be cultivated by it. The practical limit is the amount of land a work animal can cultivate between May 5 and August 1. From the 87 days of this period something over 12 must be deducted for Sundays, and as there is an average of 28 days' rain at this season in the cotton belt on which no plowing can be done, deduction must be made for these also, leaving 46 working days. Four plowings, sometimes more, must be given in good cultivation, which would leave $11\frac{1}{2}$ days for each plowing. A day's work being 3 acres, the horse would work $34\frac{1}{2}$ acres. By following out this calculation a good idea of the cost of production under present conditions of cotton culture may be obtained. To prepare the land it should be broken up at the rate of an acre a day, but as this is rarely done more than once in three years, one-third only is to be charged, say, 11 days' work on this account; the laying off, bedding, dragging off, and planting will require a little over nine-tenths of a day's work per acre, or $33\frac{1}{3}$ days' work in all to prepare and plant, making a total before cultivation commences of $44\frac{1}{3}$ days' work. To this, if Sundays are added and rainy days as before, it will sum up to 67 days, and adding the 87 days for cultivation, the total is 154 days' work of a horse to cultivate a full crop of cotton. But it remains to haul the crop to the gin. Estimating the crop at the average crop of the cotton belt for the last eleven years, viz, 531 pounds of seed cotton to the acre, the mule would have to move 18,319 pounds from the $34\frac{1}{2}$ acres; at four loads of 800 pounds a day there would be 6 days' work; in all, 160 days in a year.

The cost of a horse, counting insurance, feeding, stabling, and

interest, together with the wear and tear of such gear and implements as are used in the cultivation of cotton, is fully covered by \$122.85 per annum. For the portion of the year the animal is engaged in the cotton crop this would be \$53.92. The wage of the plow hand for the crop may be put at \$64. Four hoeings would cost for the $34\frac{1}{2}$ acres \$55.20, making the total cost to date of picking and cultivating $34\frac{1}{2}$ acres in cotton \$173.12. Picking the amount stated above, as an average crop, would cost \$73.27. In all, the cost for delivering at the gin-house 18,319 pounds of seed cotton would be \$246.39, or 1.344 cents per pound.

If fertilizers are used at the rate they were used in 1890 in Georgia and South Carolina, \$1.78 an acre must be added on that account, bringing it up to \$307.80, or 1.68 cents per pound of seed cotton.

It remains to mention rent, taxes, and management. As the latter consists almost wholly in seeing that advances are charged against the laborers and in collecting such due as it is not difficult to get, 5 per cent commissions on the profits would be a fair allowance. Taxes are so inconsiderable that they do not merit notice. With rent it is different; economic rent does not exist in this country; the most usual rent has been a portion of the crop, and one-fifth to one-fourth of the cotton produced has been paid. Nevertheless rents have differed a good deal; in the east \$2 to \$3 has been a fair average; in the west, in the Mississippi bottoms and the black prairies it has run from \$4 to \$10 an acre. The low prices of cotton have changed this, and in some sections, even of the black prairies of Texas, tenants have been notified by merchants that they could not advance to them in 1895 if they paid a money rent exceeding \$3 an acre. It is safe to say that this year an average rent is \$1.50 an acre in the east and \$3 in the west. The first amount is to be added to the cost of production where fertilizers are used, and the latter where they are not used. This addition makes the cost of a 1-horse crop exclusively in cotton in the east sum up to \$359.55, or to 1.96 cents per pound of seed cotton; in the west the result will be \$349.89 for a similar crop, or 1.88 cents per pound of seed cotton. This would be very nearly a cost of 5.88 cents per pound of lint in the east and 5.68 cents in the west for cotton delivered at the ginhouse, the cost of ginning and packing remaining to be counted, the value of the seed more than sufficing for this in both instances. The seed commands a higher price in the east, and would tend by its sale to render the cost more equal. Though worked out by a different method, these results will be found to differ little from an average of the various estimates already given.¹ The percentage of the cost of labor on the total cost of production is 53 per cent in the east and 55 per cent in the west. This is a much higher ratio of the cost of labor than will be found in

¹It should be clearly understood that none of these estimates do more than indicate the probable cost of cotton production, assuming certain prices and conditions which may or may not obtain in any given case. They may approximate the average cost of production under present systems of cotton culture in the South, but they by no means show the minimum of cost under the most improved methods.—Ed.

most other industries. In averaging the percentage of the cost of labor to total cost in 10 cotton mills taken at random from among the Northern mills, and the same number from the Southern, the first is 33 per cent and the second 22 per cent. Labor is thus seen to be the predominant element in cotton growing.

Modern improvements in machinery, which have so wonderfully affected most industries, have only indirectly benefited agriculture, and cotton culture as little as any branch of this pursuit. Great improvements have been made in agricultural machinery, but the share worker and small tenant, even the one-horse farmers, whose numbers are rapidly multiplying in the cotton-growing region, are not able to avail themselves of such helps. The improved implements are as a rule the property of another class, and the profit from their use goes almost exclusively to their owners.

It costs as much in human labor to prepare, plow, hoe, and pick an acre of cotton now as it did half a century ago, and if the product is increased by the successful use of commercial fertilizers, such use necessitates an increase of labor in the preparation for and the culture and gathering of the product. On the other hand, the agricultural laborer finds in strikes no resource to benefit him. The seasons inexorably fix the day and hour when his services are needed; if he allows it to escape him, it is gone once for all, and with it disappears the product out of which alone wages are paid. The employer also can not resort to lockouts. The manufacturer may suspend operations and lose little besides the interest on his plant. Such a suspension even for a brief period of farm work would mean the loss of the entire season's work.

The small farmers, working on a narrow margin, are always in imminent need of cash, and cotton is the only crop that never fails of a ready cash sale. Every pound of it can be readily disposed of by the producer for cash, and at the prices quoted in the markets of the world. All other crops, unless grown upon a scale suitable for shipment in bulk—a scale seldom within the reach of the small farmer—are subject to the vicissitudes of the local market, easily overstocked, and often inflicting heavy loss on the producer of perishable commodities.

The general testimony is that, while farmers growing cotton exclusively are in very bad condition financially, those who raise food and forage crops, and especially those who in addition raise their work animals, are everywhere prosperous. The chief reason of this is, as has been shown, that the exclusive cotton grower fails to employ the most important forces in farm work, the work animals and the land, to the fullest extent. He draws upon the surplus of a single crop made in part of the year for the means to support his farm during the whole year. There is a saving in using unemployed time and capital to produce necessities which otherwise must be paid for in money. The tendency to pay greater attention to food and forage crops has been much accelerated by the low price of cotton since 1890.

COTTON PRODUCTION IN DIFFERENT STATES.

The usual method pursued in collecting and arranging the data of cotton production has been to do this by States. The attempt has been made in this article to marshal these data in what seemed to be the important natural subdivisions or regions of the cotton belt without confining them within State lines. These natural subdivisions are substantially those adopted by Professor Hilgard in his work on cotton culture for the Tenth United States Census. It was thought that these regions of the cotton belt possessed well-marked characteristics of soil, growth, products, climate, and methods of culture, together with racial, social, and industrial peculiarities, all of which were influenced only in a very small degree by the political boundaries of the States. Therefore it would seem that the understanding of these real and natural regions is more important to a knowledge of the conditions of cotton culture and production than the artificial political framework of the States. But as the production of cotton by States may be of interest, the following data are given:

Percentage of cotton crop grown in each State.

State.	1799.	1809.	1819.	1829.	1839.	1849.	1859.	1869.	1879.	1889.	1890.	1891.	1892.	1893.	1894.
Texas.....						2.4	8.0	11.6	14.2	19.8	23.0	26.8	31.1	27.3	33.1
Georgia.....	27.7	25.0	25.0	21.4	20.6	20.2	13.0	15.6	14.2	16.0	14.6	13.4	14.0	14.9	13.2
Mississippi.....			6.2	13.3	24.6	19.6	22.4	18.8	16.7	15.8	14.6	13.9	11.3	12.1	12.1
Alabama.....			12.5	14.7	14.7	22.8	18.5	14.3	12.3	12.2	12.2	11.9	11.0	12.3	10.1
Arkansas.....				1.2	0.7	2.7	6.8	8.2	10.5	9.3	9.6	8.8	7.9	8.4	8.6
South Carolina.....	44.5	50.0	27.5	18.3	7.8	12.2	6.5	7.3	9.1	10.0	8.8	8.7	9.4	9.9	8.0
Louisiana.....		2.5	6.3	12.4	19.3	7.3	14.5	11.6	8.8	8.9	7.3	7.0	5.0	5.4	6.0
North Carolina.....	11.2	8.5	6.2	4.7	6.5	2.9	2.7	4.6	6.8	4.5	4.3	5.4	5.5	5.6	4.7
Tennessee.....	3.3	4.0	11.3	12.0	3.1	7.9	5.5	6.0	5.8	2.5	2.5	3.6	3.9	3.4	3.5
Florida.....					1.5	1.9	1.2	1.3	0.9	0.7	0.6	0.3	0.6	0.6	0.6
Others.....	13.3	10.0	5.0	2.0	1.2	0.1	0.9	0.7	0.7	0.3	3.1	0.2	0.3	0.1	0.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The above table presents a general view of the order of development of cotton growing in the different States. It shows the extraordinary expansion of the industry in the extreme West, but the success with which the Eastern States have kept up their ratio of percentage to the whole crop for half a century demonstrates the deep root this culture has taken in those States.

Average annual yield per acre of cotton in different States.

State.	Pounds of lint cotton per acre.														Maxima.	Minima.	Average.
	1874.	1876.	1879.	1880.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
N. Carolina..	153	151	195	198	180	175	174	176	157	196	202	140	218	194	183	168	180
S. Carolina....	137	144	172	185	183	134	138	148	140	168	155	180	215	204	184	168	201
Georgia.....	124	136	140	163	152	122	124	146	137	158	159	170	197	180	160	169	206
Alabama.....	111	135	136	154	150	120	110	125	130	135	136	165	165	179	135	200	208
Mississippi..	150	185	202	172	190	185	170	175	178	196	192	200	230	252	190	190	208
Louisiana.....	199	195	263	182	235	254	243	224	221	228	206	252	293	373	260	256	357
Texas.....	150	204	167	230	240	244	142	175	200	163	164	183	233	260	291	239	383
Arkansas....	124	200	263	215	243	221	193	209	240	233	230	201	290	335	265	188	227
Tennessee...	133	154	204	203	170	194	174	172	171	168	169	126	198	225	172	165	229
Cotton belt..	139	171	177	188	200	157	150	165	162	177	169	172	220	247	205	194	254

¹ Minimum yield.² Maximum yield.

This table is an approximate estimate of the product, in pounds, of lint cotton per acre of each State.¹ For the first eight years recorded the average yield was 168 pounds lint per acre; for the ninth year it was 177 pounds, and for the eight succeeding years 204 pounds of lint per acre. The improvement seems to have been very uniform in all the States. The maximum yields have been made in the last five years and the minimum yields in the years previous. It goes to show that there is a steady and progressive improvement in the culture of cotton which must distance foreign competition. It will be noticed that the difference between the maximum and minimum yields is greatest in the States making the greatest yields, which are also those States that have entered most recently on cotton growing. The fluctuations are largely due to the variations in the seasons. Thus, in North Carolina the minimum and maximum yields stand side by side in the years 1889 and 1890. It seems, however, by no means probable that the steady increase in the yield per acre is in any considerable degree due to more favorable seasons.

The following table gives the United States Department of Agriculture estimates of the total production of cotton in the different cotton-producing States during the years 1894 and 1895:

Cotton crops of 1894 and 1895, by States and Territories.

States and Territories.	Acres.		Bales.		Bales per acre.	
	1894.	1895.	1894.	1895.	1894.	1895.
Alabama.....	2,664,861	2,371,726	854,122	663,916	0.32	0.28
Arkansas.....	1,483,319	1,186,655	709,722	520,860	.48	.44
Florida.....	201,621	191,540	48,005	38,722	.24	.20
Georgia.....	3,610,968	3,069,323	1,183,924	1,067,377	.33	.35
Indian Territory.....	233,898	212,847	104,887	68,668	.45	.32
Kansas.....	168	40	67	15	.40	.38
Kentucky.....	8,243	.....	2,685	.....	.33	.....
Louisiana.....	1,313,296	1,142,568	721,591	513,843	.55	.45
Mississippi.....	2,826,272	2,487,119	1,167,881	1,013,358	.41	.41
Missouri.....	63,696	47,772	24,114	11,816	.38	.25
North Carolina.....	1,296,522	1,050,183	454,920	397,752	.35	.38
Oklahoma.....	28,992	26,093	13,001	14,103	.45	.54
South Carolina.....	2,160,391	1,814,728	818,330	764,700	.38	.42
Tennessee.....	879,954	712,763	286,630	172,560	.33	.24
Texas.....	6,854,621	5,826,428	3,073,821	1,905,337	.45	.33
Utah.....	.....	400	.....	103	.....	.26
Virginia.....	61,128	44,623	12,735	7,964	.21	.18
Total.....	23,687,950	20,184,808	9,476,435	7,161,094	.40	.35

NOTE.—The figures given in this table were secured by a method adopted by this Department in September, 1894, with the view to giving the planter reliable information as to the crop of the year before the beginning of the following season. The cooperation of all railway and water transportation companies and cotton mills operating in the cotton States, as well as all custom-houses and several thousand cotton buyers, merchants, and ginneries in those States, was secured in reporting data relating to the movement and consumption of cotton and interior stocks on hand. The estimates from data thus secured are made as follows: The movement from all interior points in each State across its boundaries is carefully investigated, and the movement to the ports of a State is included with the movement from the State, because practically all receipts at ports in the cotton section are ultimately shipped coastwise to Eastern points or exported. From the reserve stocks of the State the cotton at its ports is therefore excluded, being already accounted for in the railway and water movement. Further deduction is necessarily made of cotton shipped from one cotton State to interior points in another. In the season 1894-95 the movement was followed from September 1, 1894, to April 1, 1895; in 1895-96 it was followed during the entire season, from September 1, 1895, to August 31, 1896.

¹The data are obtained from the United States Census returns for the years 1879 and 1889, from the reports of the United States Department of Agriculture, from Latham, Alexander & Co.'s Cotton Movement, and from Shepperson's Cotton Facts.

EXPERIMENTS IN COTTON CULTURE BY THE EXPERIMENT STATIONS.

The agricultural experiment stations in the cotton belt have conducted relatively few field experiments on cotton culture, their work in this line having been largely confined to the best distance between the plants and the effects of topping. While the results of these experiments have not been conclusive, some of them afford suggestions of value to the planter and the experimenter. The following brief summary, prepared by Mr. J. F. Duggar, of this office, presents an outline of the work of the stations in this line, with references to the published reports:

In a single test at the Alabama Canebrake Station, planting on high beds resulted in a larger yield than was obtained with flat beds on a black slough bottom, a kind of soil which is very retentive of water. There was only a very slight difference in yield between ridges made on an unbroken center and those formed by bedding on a center furrow. The usual recommendation of the stations is to plant on low or flattened ridges.¹

At Camden, Ark., on a field previously planted in corn, a larger yield was obtained by breaking the land and then forming the beds than by making the ridges without previous plowing, the difference being 292 pounds of seed cotton per acre. On ridges made in February the yield was slightly greater than on those made just before planting in May.²

Subsoiling proved profitable in one test made at Athens, Ga.; and in the same locality results favored planting later than April 10.³

At the Alabama Canebrake Station cotton growing on tile-drained land was in most seasons more productive than on undrained land.⁴

The depth and extent of the root growth of a plant furnish suggestions as to methods of preparing and tilling the soil. At the South Carolina Station the taproot of the cotton plant extended to a depth of more than 3 feet when the plant was grown on a light sandy soil, with subsoil of the same character. On a loam with a more compact subsoil the taproot terminated abruptly as soon as the hardpan was encountered at a depth of 9 inches below the surface. At the Alabama College Station the taproot penetrated vertically to a depth of 12 inches, or 3 inches into the subsoil, its course then becoming horizontal.

In South Carolina it was observed that most of the lateral roots commenced about 3 inches below the surface, and never went below the upper 9 inches of soil.

¹ Alabama Canebrake Sta. Bul. 4.

² Arkansas Sta. Bul. 28.

³ Proc. Georgia State Agl. Soc., Feb. 1874, p. 67.

⁴ Alabama College Sta. Bul. 4 (1887), Bul. 3 (1888); Alabama Canebrake Sta. Buls. 11 and 14.

In a garden soil of sandy drift and pebbles the Alabama Station found a young cotton plant $3\frac{1}{4}$ inches high having one of its lateral roots 3 feet 4 inches long, the end of the root being only 3 inches below the surface. Almost identical measurements were made of the roots of a young cotton plant at the Arkansas Station. In Alabama, from a cotton plant 2 feet high and just beginning to bloom, one lateral root extended more than 5 feet. Some of the lateral roots began only $1\frac{1}{2}$ or 2 inches below the surface. The position of the roots was such that the experimenter estimated that the usual deep cultivation would have destroyed four-fifths of the lateral roots which extended at right angles to the row.

In this we have a strong hint as to the superiority of shallow over deep cultivation, a superiority which was proved by experiments extending over several years at the Alabama College, Alabama Canebrake, Georgia, and Mississippi stations. We find only two instances in which shallow culture failed to afford a larger yield than deep culture.¹

At the Georgia Station an experiment to determine the best distance between cotton plants was conducted in five different years. The rows were uniformly 4 feet wide, and the attempt was made to leave single plants either 1, 2, 3, or 4 feet apart in the drill. It generally happened, however, that the stand was much more imperfect on the plats planted close than on the others. This is equivalent to saying that the least average distance between plants was somewhat greater than 12 inches. The following table gives the yields obtained each year with different distances, on land heavily fertilized:

Yield in pounds per acre of seed cotton from planting at different distances.

Year.	1 by 4 feet.	2 by 4 feet.	3 by 4 feet.	4 by 4 feet.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1891.....	1,943	2,027	2,007	1,833
1892.....	1,616	1,516	1,501	1,439
1893.....	1,903	1,905	1,925	1,770
1894.....	2,065	1,812	1,843	1,671
1895.....	2,270	2,047	1,985	1,767
Average of 5 years.....	1,960	1,861	1,852	1,696

The figures giving the average yield for five years indicate that even on land so rich or well fertilized as to produce $1\frac{1}{3}$ bales of cotton per acre, a distance of 4 feet in the row between plants reduces the yield considerably. On the whole the results seem to indicate that with 4-foot rows, when the date of planting is rather late, there is an advan-

¹Alabama Canebrake Sta. Bul. 4; Alabama Dept. of Agr. Bul. 6 (1886); Alabama College Sta. Bul. 4 (1887), Bul. 3 (1888); Arkansas Sta. Rpt. 1888, p. 117; Georgia Sta. Buls. 11 and 16; Mississippi Sta. Rpt. 1889, p. 13, Rpt. 1890, p. 16; South Carolina Sta. Rpt. 1889, p. 84.

tage in spacing cotton plants 12 to 16 inches rather than in allowing more room in the drill.

The experimenter, however, in summing up the results for the five years, expresses a preference for a distance of 2 by 4 feet when early planting is practicable and when a yield of 1,800 to 2,000 pounds of seed cotton can be expected. In this case early thinning and rapid and thorough cultivation are recommended.

That close planting favors early maturity, and hence is desirable when the date of planting is late or where the growing season is short, as in the northern part of the cotton belt, is indicated by the following facts noted in the experiment of 1892: The total yield varied little for plantings at different distances, but at the first picking the yields for distances of 1, 2, 3, and 4 feet were 593, 449, 323, and 221 pounds, respectively. At the second picking the yield was again greatest with close planting. However, at the third picking the yield was greater as the distance was greater, and this was yet more strikingly true at the fourth picking, showing the tendency of wide spacing to delay maturity.

The yield of seed cotton per plant as influenced by distance in the drill was determined in the same experiments, as follows:

Yield of seed cotton per plant at different distances in rows 4 feet apart.

Year.	1 foot.	2 feet.	3 feet.	4 feet.
	<i>Pound.</i>	<i>Pound.</i>	<i>Pound.</i>	<i>Pound.</i>
1891.....	0.210	0.405	0.565	0.687
1892.....	.169	.287	.423	.542
1893.....	.275	.417	.561	.690
1894.....	.243	.325	.483	.566
1895.....	.275	.411	.557	.665
Average of 5 years.....	.234	.369	.518	.626

From this table we see that with plants at a little more than 12 inches apart each plant averaged more than one-fifth pound of seed cotton; at 2 feet apart, a little more than one-third pound; at 3 feet apart, one-half pound; and at 4 feet, five-eighths pound. The yield per plant varied greatly in different years. In this connection it should be remembered that the minimum yield in these experiments was 1 bale per acre.

In 1893 the Georgia Station conducted an experiment to ascertain the best distance between the rows. Each plant was allowed 6 square feet of ground, one series of plats bearing plants at distances of 3 feet by 24 inches, another 4 feet by 18 inches, another 5 feet by 14.4 inches, and another 6 feet by 12 inches. The yield was greatest—1,964 pounds of seed cotton per acre—when the distance was 3 feet by 24 inches, and the yield per acre and the product per plant decreased as the rows were widened, with the accompanying closer planting in the drill. In other words, the yield increased as the space assigned to each plant

approached a perfect square. A repetition of this test in 1895 confirmed the results of 1893. "On land of less capacity than 1 bale per acre it would probably be well to reduce the width of rows to $3\frac{1}{2}$ or even 3 feet. It may be safely urged that land which will not produce the maximum crop of which it is capable with rows not less than 3 feet wide can not profitably be cultivated in cotton."¹

In a test made by the University of Georgia, at Athens, the yield decreased very slightly and very gradually as the rows widened from $2\frac{1}{2}$ to 4 feet, the difference being scarcely sufficient to pay for the extra expense of cultivating narrow rows. In this experiment the plants stood close together in the row—10 to 15 inches apart—and the yield averaged a little more than half a bale per acre. On the same field single stalks and groups of 2 and 3 plants were left in a place, the interval for all being the same—10 to 15 inches. The yields were practically identical.² Other experiments, notably those conducted at the North Louisiana Station, suggest that the cotton plant, under some conditions, does not suffer from the presence of 2 stalks in a place, a point of advantage where planting in checks is desirable.

At the North Louisiana Station it was found in 1888 that with close planting in the drill every increase in the width of the row beyond 4 feet reduced the yield. As between narrower rows the results were not conclusive.³

In 1889 single stalks were left 8, 12, 16, and 20 inches apart in the drill; 2 stalks in a place were also left at these distances and at 24 inches apart. The maximum yield of seed cotton was $1\frac{1}{3}$ bales per acre. Whenever the distance was greater than 16 inches, the yield decreased whether 1 or 2 plants stood in a place. Even closer planting seemed to be slightly advantageous.⁴ The above-mentioned experiment was repeated in the following year, when the maximum yield of seed cotton—1,690 pounds—was obtained on the rows in which 2 plants stood together at intervals of 16 inches. For distances greater than 16 inches the yield decreased as in the preceding year, both for 1 and 2 stalks in a place. With single stalks the yields at 8, 12, and 16 inches were practically identical. Planting at a distance of 16 inches has the advantage of rendering cultivation easier than closer planting.⁵ When again repeated in 1891 the maximum yield—1,800 pounds of seed cotton per acre—was obtained on the 2 plats having 2 stalks in a place at intervals of both 16 and 24 inches. For single stalks distances of 16 and 20 inches proved of equal value, and yielded more than closer planting.⁶ The next year the maximum yield—960 pounds of seed cotton per acre—was obtained from 2 stalks in a place at intervals of 24 inches.

¹ Georgia Sta. Buls. 11, 16, 20, 24, and 27.

² Proc. Georgia State Agl. Soc., Feb., 1874, p. 67.

³ Louisiana Stas. Bul. 22 (old ser.).

⁴ Louisiana Stas. Bul. 27 (old ser.).

⁵ Louisiana Stas. Bul. 8 (2d ser.).

⁶ Louisiana Stas. Bul. 16 (2d ser.).

Single stalks were most productive at distances of 16 and 20 inches, yielding, respectively, 910 and 920 pounds of seed cotton.¹ In 1893 the greatest yield—1,160 pounds of seed cotton per acre—was produced by 2 stalks together at a distance of 24 inches. Single stalks at intervals of 12 inches gave a yield almost identical with the above—1,140 pounds per acre.²

In 1892 early maturity was apparently favored by rather close planting; at the first picking the single stalks or groups of two growing at intervals of 12 inches had matured a larger proportion of their total crop than had the plants grown at any other distance. In 1893, however, close planting did not notably increase the proportion of total yield secured at the first picking.

In 1893 at the experiment station at Baton Rouge, La., 1 and 2 stalks were left at intervals of 12, 18, and 24 inches in rows 3, 4, and 5 feet apart. In rows 3 feet and 4 feet apart, a distance of 18 inches between single plants afforded the largest yield; in rows 5 feet apart, 12 inches between plants in the drill proved best. The greatest yield for single stalks, 2,037 pounds of seed cotton per acre, was obtained when the distance was 18 inches by 3 feet; in other words, when the feeding area of each plant approached nearest a square. When 2 stalks were left in a place the greatest yield on any plat was obtained by planting at distances of 2 by 3 feet; in 4-foot rows, 18 inches gave the largest yield, 1,734 pounds; in 5-foot rows the yield increased with the distance between the groups of plants.

Taking the average results of all distances with both 1 and 2 stalks in a place, the yield of seed cotton per acre was 1,821 pounds on the 3-foot rows, 1,557 pounds on the 4-foot rows, and 1,540 pounds on the 5-foot rows. With single stalks 3-foot rows and 4-foot rows afforded practically identical yields when the distance between plants was 1 foot; at greater distances in the drill 3-foot rows proved superior. With 2 stalks in a place 4-foot rows proved most productive except when the distance in the drill was extended to 2 feet, when 3-foot rows gave the largest yield obtained on any plat. In this experiment distance of planting did not notably affect the earliness of the crop.³

The South Carolina Station conducted experiments on the subject extending over several years at three different localities in the State. The average results showed only very slight differences in yield, whether the rows were $3\frac{1}{2}$, 4, or $4\frac{1}{2}$ feet apart.

In the South Carolina tests when checking was practiced there were no constant differences in yield, whether the distance was $2\frac{1}{2}$ or 4 feet between the hills. In comparing drill culture with checking the average results of a number of experiments were quite similar, indicating no marked differences in yield between the two systems.⁴ At the North

¹ Louisiana Stas. Bul. 22 (2d ser.).

² Louisiana Stas. Bul. 29 (2d ser.).

³ Louisiana Stas. Bul. 28 (2d ser.).

⁴ South Carolina Sta. Rpt. 1888, p. 274; Rpt. 1889, p. 324; Bul. 2 (n. ser.); see also Georgia Sta. Bul. 11.

Carolina Station, in 1886, checks 2 feet by 3 feet and 3 feet by 3 feet afforded practically the same yields—nearly $1\frac{1}{2}$ bales per acre—but planting at distances of 4 feet by 4 feet greatly reduced the yield. At distances of 2 by 3 feet the crop matured somewhat earlier than on plats where more space was allowed each plant.¹

At the Alabama College Station cotton was planted in 1886 at intervals of 1, 2, 3, and 4 feet, in 4-foot rows. The closest planting yielded slightly more, the widest spacing somewhat less, than did the intermediate distances. The yields at different distances ranged between 1,085 and 1,292.5 pounds of seed cotton per acre.²

Distance experiments were also made in 1889 and in 1890 without decisive result, the figures in the latter year suggesting a slight superiority of a distance of 2 by 4 feet as against 1 by 4 feet, 3 by 4 feet, and 4 by 4 feet, the yield being at the rate of about two-thirds of a bale per acre. Close planting hastened maturity.³

In 1891 Welborn Pet, a cluster variety, planted in rows 4 feet apart, yielded 2,519 pounds per acre of seed cotton when the interval between plants was 1 foot, 2,010 pounds when the plants were 2 feet apart, 2,077 pounds at 3 feet, and only 1,145 when the distance was increased to 4 feet.

Peeler, a long-limbed variety, in 4-foot rows yielded at 2 feet 1,983 pounds, at 3 feet 1,487 pounds, at 4 feet 1,453 pounds, and at 5 feet 1,333 pounds of seed cotton per acre.⁴

At the Alabama Canebrake Station, on slough bottom land, a distance of 3 by 4 feet resulted in a yield of 952 pounds of seed cotton per acre, against a crop of 896 pounds obtained on the plats where the spacing was 1 by 4 feet, 2 by 4 feet, and 4 by 4 feet.⁵

At the same station in the following year the yield per acre of seed cotton in 4-foot rows was as follows: Plants 1 foot apart, 1,216 pounds; 2 feet, 936 pounds; 3 feet, 760 pounds; 4 feet, 880 pounds.⁶

From the results just summarized it appears that there has been found no definite law determining the proper distance applicable to all conditions. The results thus far attained by the stations relative to distance between cotton plants, though not capable of generalization, afford useful hints to cotton growers whose soils resemble those of the different experiment stations. Future investigations may result in rules of practice applicable to certain characters of soil and varieties of cotton. At best, however, variations in weather, which can not be foreseen, will limit the application of such rules.

Rotation experiments have for some years been in progress at the Arkansas and Louisiana stations, but in the nature of the case

¹ North Carolina Sta. Rpt. 1887, p. 127.

² Alabama College Sta. Bul. 4 (1887).

³ Alabama College Sta. Buls. 4 and 22.

⁴ Alabama College Sta. Bul. 33.

⁵ Alabama Canebrake Sta. Bul. 3.

⁶ Alabama Canebrake Sta. Bul. 4.

conclusive results are not to be expected until many crops have been grown.¹

Five hundred bolls of the Peerless variety were selected at the Arkansas Station, from the bottom and from the top of well-developed stalks, the seed cotton from 500 bottom bolls weighing 8.26 pounds, from 500 top bolls 6.46 pounds. On planting the seed of these two lots of cotton, the seeds from bottom bolls germinated much better and more promptly than those from top bolls. The former also matured earlier and afforded a larger yield—1,043 pounds of seed cotton per acre, as against 760 pounds from seed obtained from top bolls. The more complete and earlier sprouting of the seed from bottom bolls may have been the cause of the earlier maturity and greater productiveness of the resulting plants, for two replantings of seed from top bolls were necessary, and even then only about half a stand was obtained, while seed from bottom bolls afforded an excellent stand without replanting. But it does not appear whether the position on the parent plant, the greater size of bottom boll seed, or some other condition was the cause of the earlier and more complete germination of the seed from bottom bolls. Further experiments are needed to fully establish the difference, if any, in the germination and productiveness of seed from different parts of the cotton plant.²

Experiments intended to ascertain the effect of topping cotton have been conducted by the Alabama Canebrake, Alabama College, Georgia, Louisiana, Mississippi, and South Carolina stations, and by the University of Georgia. In only one of these experiments, that of the Alabama Canebrake Station, were the results decisively in favor of topping. In one year of the test at the Alabama College Station the figures slightly favored topping, though in the preceding year the slight advantage was with the plants not topped. The Georgia Station, in 1890 and 1891, obtained a smaller yield from topped plants than from those not topped. Here, as in several other experiments bearing on this question, the effect of topping at different dates was studied, and the single exception to the injurious influence of this mutilation occurred in 1891 on the plat where it took place late, August 15. The earlier the topping the greater was the injury in these experiments. At the Mississippi Station topping as late as September 20 resulted in a large shrinkage in yield.

The South Carolina Station conducted experiments in two localities in that State during three years without being able to observe any perceptible variation in yield between plants topped and those not topped.

A single test at the North Louisiana Station, in which plants growing at different distances were topped, revealed no marked effect for good or ill resulting from this practice.

¹ Arkansas Sta. Bul. 23; Louisiana Bul. 17 (n. ser.).

² Arkansas Sta. Bul. 23.

Topping has given contradictory results under different conditions. Differences in soil and climate are probably responsible for this, and it remains for future experiments to determine the conditions under which topping is beneficial or otherwise.

In a single test made by the University of Georgia the yield on the plats where topping was practiced was 1,303 pounds of seed cotton and on the untreated area 1,387 pounds; the loss of 84 pounds was ascribed to topping. The prominent feature of this experiment was the probable influence of topping in hastening maturity, the topped plants yielding 47 per cent more at the first picking than did the plants not topped. This increased earliness, if it could be fully established, might explain the occasional success of topping, and would recommend the practice for late varieties and for localities where the growing season is short. However, two experiments on a more extensive scale at the Georgia Station fail to show any perceptible increase in earliness as the result of topping. In future experiments in topping cotton it is to be hoped that its possible influence on early maturity of the plant will be observed. The detailed results of experiments in topping cotton may be found in the following publications:

Alabama College Sta. Bul. 4 (1887), Bul. 4 (1888); Alabama Canebrake Sta. Bul. 4; Proc. Georgia State Agl. Soc. Feb., 1874, p. 67; Georgia Sta. Buls. 11 and 16; Louisiana Stas. Bul. 27 (old ser.); Mississippi Sta. Rpt. 1889, p. 13; South Carolina Exptl. Farm Rpt. 1883-1886, p. 33; South Carolina Sta. Rpts. 1888, p. 281, 1889, p. 332, and Bul. 2 (n. ser.).

DISEASES OF COTTON.

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GENERAL NATURE OF COTTON DISEASES.

Investigations, continued for several years, have brought to light several quite well characterized maladies of the cotton plant in the United States. Some of these are physiological in their nature, being due to disturbances of nutrition and assimilation.

Other diseases of this plant are due to the action of fungus organisms, which live as parasites in various parts of the plant, consuming the nutriment and causing destructive changes, which bring about the death of the part attacked if not of the entire plant. The term "rust," frequently defined as "red rust" or "black rust," has become so general in its application as to be utterly valueless other than in conveying the notion of disease. If we accept the term "cotton rust" as simply synonymous with cotton disease, it will tend to eliminate much of the confusion which must necessarily result should the term be accepted for any single disease, and the great indefiniteness which has clustered around this term as a name for a single disease will be cleared away. By the application of appropriate names to carefully discriminated conditions of the plant, much progress will be made in the understanding and treatment of these troubles.

The purpose of the present article is to present a résumé of the results of the investigations upon cotton diseases in the United States, some of which have already been published.

These diseases may be classed in three general divisions, according to their etiology.

Diseases due to physiological causes.—Mosaic disease, or yellow leaf blight, red leaf blight, shedding of bolls, and angular leaf spot.

Fungus diseases.—Frenching; sore shin, damping off, or seedling rot; anthracnose; root rot; cotton-leaf blight; areolate mildew; cotton-boll rot; and ripe decay of bolls.

Nematode diseases.—Root galls.

MOSAIC DISEASE, OR YELLOW LEAF BLIGHT.

The later stages of this disease probably form the larger part of the troubles which are termed "black rust." The name mosaic disease, or yellow leaf blight, is quite characteristic of the early stages of the trouble as it is here defined, and renders it possible to differentiate it

readily from the other troubles, which are often spoken of as "black rust," but which are in reality quite different in their nature. The term "yellow leaf blight" was first used by the author in 1892.¹ "Mosaic disease" was added to this term, or used synonymously, a few months later.² The latter seems the more appropriate, but since the former was first used in differentiating this peculiar disease from the others it seems well at least to continue its use in the literature of the subject for the present. During very rapid progress of the disease also the mosaic character of the leaf is not so apparent as during the normal development.

In 1891 a preliminary investigation of the so-called black rust was made.³ The study was confined entirely to the organisms present on the leaf and other parts of the plant, and it was not possible at that time to do more than to record the presence of certain fungus organisms, to observe their botanical characters, and to note the fact that their presence at least hastened the destruction of the plant.

The following year investigations taken up at the beginning of the season confirmed the view that the organisms hastened the destruction of the plant, and at the same time demonstrated the fact that the organisms did not initiate the disease but only aggravated it.

The results of the trials of Bordeaux mixture, can celeste, and copper sulphate indicated that this disease could not be prevented by the application of fungicides, and confirmed the conclusion, drawn from observations of a different character, that it was due to physiological causes.

Experiments conducted under the direction of the author in several localities in Alabama during two seasons showed a considerable reduction of the disease on plats where kainit was the fertilizer used.

At Auburn an experiment was conducted on three plats. Plat No. 1, on which cowpeas had been grown, received before plowing a heavy dressing of kainit and acid phosphate. No nitrogenous fertilizer was applied. Plat No. 2 received nitrate of soda in addition to other fertilizers but no kainit. Plat No. 3 received a complete fertilizer. In July there was a perceptible yellowing of the plants in plat 1, while plats 2 and 3 bore a rich green foliage. The yellow color of the plants in plat 1 was evenly distributed over the leaf, there being no indication of the mosaic arrangement so characteristic of the disease. In September the plants were matured and only a few showed any sign of the disease. The yellow color of the plants was due to the acid phosphate and kainit ripening the plants prematurely (acid phosphate being known to produce this effect), along with a suffused yellowing of the plants.

Early in August the plants in plats 2 and 3 were badly affected, the

¹ Alabama College Sta. Bul. 36.

² Alabama College Sta. Bul. 41.

³ Alabama College Sta. Bul. 27; Bot. Gaz., 16 (1891), No. 3, pp. 61-65.

leaves showing the checkered appearance of the disease, and were an easy prey for such fungi as *Macrosporium nigricantium* and *Cercospora gossypina*, resulting in their curling up, drying, and falling off.

In a field of cotton of 3 or 4 acres near the scene of the above experiment the plants in May and June were very promising, but in August the disease had appeared to such an extent that the yield fell off at least one-half of what would have ordinarily been expected. The fertilizer used in this case was stable manure, cotton seed, and acid phosphate.

These experiments seem to show what has for some time been held by a number of intelligent planters who have experimented with kainit as a fertilizer. It has been quite frequently noted that with quite large applications of kainit there was no appreciable increase in the yield of cotton. This occurs in those seasons when the rains are quite frequent, not long continued, and keep the soil moist and the plant in normal growth. On the other hand, during dry seasons as well as seasons of drought followed by long-continued rains, kainit has a perceptible, sometimes a remarkable, influence in increasing the yield. This, with the well-known effect of such salts in changing the physical condition of the soil, leads to the belief that the increased yield and the comparative freedom from disease result from the action of the kainit in binding more firmly together the soil particles, so that it is more retentive of moisture or more able to draw it up from below.¹ Salt and wood ashes are known to produce much the same results in the soil.² Rolling the land is frequently resorted to in order to produce the same effect. In the cultivation of cotton the more progressive planters are careful to prepare the land well before planting, and then to cultivate only the surface soil afterwards, in some cases scraping the surface of the soil with a "sweep" to a depth of only a few inches. This leaves the underlying soil undisturbed, and there is no break in the continuity of the surface film on the soil particles below the few inches which have been stirred. The few inches of soil which have been stirred thus act as a mulch.

Characters of the disease.—In the normal and usual progress of the disease there first appears a peculiar yellowing of the leaf, which gives it a checkered or mosaic appearance. The yellow color appears in small areas and bears a definite relation to the venation of the leaf, being bounded by veinlets which subtend areas more or less rectangular in outline. The green color is found along the larger and intermediate veins. The portions of the mesophyll lying along the veins, being near the channels for the distribution of the nutriment, receive a better supply of moisture and assimilative material than the areas farther away and those along the smaller and terminal ramification of the vascular channels at a time when the supply is being cut short because of unfavorable conditions of the soil. They are thus enabled to hold the green

¹ Alabama College Sta. Bul. 36.

² See article on climatology and soils, p. 160.

color and continue the activities of the leaf for a longer period, while the angular areas most remote from the sources of supply are the first to feel the loss, and the deficient nutrition is manifested by the yellow color of the parts.

During the first stages of the disease this color may become very pronounced, but later it may be marred by the appearance of discolored spots produced by the growth of fungus organisms in the tissues, weakened by the failing nutrition of the plant. Soon, however, there appear minute brownish spots in the yellowish areas, which increase in size cen-



FIG. 4.—Mosaic disease, or yellow leaf blight—*Macrosporium* form.

trifugally, assuming a circular outline and marked by concentric rings. The concentric rings are probably due to the periodic growth of the fungus threads within the tissues, the periodicity being produced by variations in the temperature. The first fungus, which in most cases appears following the mosaic condition of the leaf, is *Macrosporium nigricantium* A tk. As the leaf thus becomes in a badly diseased condition, the *Macrosporium* is likely to be soon followed by an *Alternaria*.¹ The black hyphæ and spores of these two fungi soon give a black appearance to nearly the entire leaf, from which the disease takes the name of "black rust." These are not,

however, the only fungi which are found as accompaniments of the later stages of the disease. *Colletotrichum gossypii* Southworth is sometimes found, and *Cercospora gossypina* Cooke, as well as its perfect stage, *Sphaerella gossypina* Atkinson, is a very common accompaniment of the trouble. The accompaniment of the *Cercospora* stage of *Sphaerella gossypina* frequently produces a separate type of the disease, especially when this fungus is more abundant than

¹This may be *Alternaria tenuis* Nees, which Gasparrini found with other molds as an accompaniment of the disease of cotton in Italy known as Pelagra. (See Gasparrini, Osservazioni sopra una malattia del cotone, etc. Inst. D'Incoraggiamento. Napoli, 1865.)

either the *Macrosporium* or *Alternaria*. This usually occurs when the disease progresses quite rapidly through the earlier stages, so that the yellow color is soon diffused somewhat evenly over the entire leaf or a large part of it.

The *Colletotrichum gossypii* Southworth will be described under the paragraph on anthracnose of cotton, and the *Sphaerella gossypina* under the paragraph on cotton-leaf blight. Brief descriptions of the others may be given here.

Macrosporium nigricantium Atkinson.

The technical description is as follows:¹

Hyphæ amphigenous, subfasciculate, or scattered, 0.050–0.140 mm. by 0.006–0.007 mm.; nodulose, septate, olive brown. Conidia 0.018–0.022 mm. by 0.036–8.050 mm., strongly constricted about the middle, stoutly rostrate at one side of the apex, smooth, transversely, longitudinally, and obliquely septate, olive brown.

From the intercellular mycelium in the leaf the hyphæ emerge to the outside, and, projecting a short distance from the surface, bear the spores at their free ends. When a spore is being produced, the hypha becomes somewhat enlarged directly below it. When the spore falls away, the hypha elongates at the end, the new growth arising from the inside of the enlargement, its contour being the same size as that of the hypha just below the enlargement. When the new growth first appears, it seems not to be connected with the enlargement, but projecting through it. As the hypha ages this appearance usually is not present and the enlargement seems to taper above into the new growth. The new growth thus formed at the end of a hypha may bear another spore, and so in favorable weather from two to eight or more spores may be borne in succession from a single hypha, the points where the successive spores were borne being just at the upper end of the successive enlargements. At the enlargements there is usually a darker band around the center. The hyphæ thus have a nodulose appearance in such species as *Macrosporium parasiticum* Thüm. As the young spore develops it is constricted in the middle before the first transverse partition is formed.

The species of *Alternaria* has not been determined. The hyphæ are scattered or loosely fasciculate, and plain, not nodulose, and by this character alone may be differentiated from the *Macrosporium*. The conidia are obclavate and borne in chains. In making microscopic preparations from the fungus on the leaf it is difficult to find the conidia in this relation, since they so easily become separated, but by making water cultures on a glass slip this manner of development is readily demonstrated.

Other saprogenous fungi frequently appear in the final stages of the disease, but there is no especial interest or importance in discussing them.

¹ Bot. Gaz., 16 (1891), No. 3, pp. 61–65.

If dry weather continues for a long period and the disease is developed, it is not an infrequent occurrence for the processes of dissolution in the leaf to continue so that the leaves curl up and fall away, and the plant may even die without the appearance of any of the organisms above described, or only a small percentage of the growth which is sure to appear if warm rains follow a drought when the disease is present.

RED LEAF BLIGHT.

The foliage of cotton frequently presents a red coloration, which is of the same nature as that displayed in what are termed "autumn leaves." It is an exceedingly common occurrence toward the maturity of the cotton, even of quite healthy and rank growth. It is of rarer occurrence, however, in alluvial and rich soils than on poor lands. It is especially common on what is known as the "upland," where the soil is worn and poor. Here it occurs quite early in the season, and cotton sometimes makes but little progress before the leaves become red, growth ceases, an early maturity sets in, and the leaves drop, while the plant bears from one to two or several bolls. The affection, if it can be so called, is usually denominated "red rust." It results from an impoverished condition of the soil, showing a lack especially of potash and nitrogen, and probably also of phosphoric acid. This can be remedied by proper fertilizing and cultivation.

A species of mite, probably *Tetranychus telarius* or a closely related species, frequently produces an injury to the leaves of cotton which causes them to redden. At the same time the under surface of the leaves, where the mites effect the direct injury, is made to appear "rusty" or "scurvy," and, with the coloration of the leaves, would naturally lead to the designation of this trouble also as "red rust." It occurs in several of the cotton-producing States, especially North and South Carolina, where it has been known to do considerable injury. At one time, before the careful tests with certain fertilizers were made and before a careful study of the physiological relations of the plant to certain physical and worn-out conditions of the soil, the author was inclined to believe that this mite was perhaps the sole cause of the so-called "red rust." That it does sometimes cause serious injury which should not in any way be confounded with the red leaf blight is certain. Some planters believe that this phase of the disease, though they do not distinguish it from the red leaf blight, is more apt to occur near barns or buildings where there are numerous weeds, while others believe that it is certain to occur where the cotton is planted adjacent to a clover field, and still others say that if an armful of clover be carried across a cotton field the disease will soon appear all along that tract. This would favor the possibility that the mites in these cases were on the clover, and it is known that in some cases they are quite common on this plant as well as others.

Literature.—"The cotton worm and other enemies of the cotton plant," G. F. Atkinson, South Carolina Dept. Agr. Monthly Rpt., Oct., 1888, p. 91. South Carolina Sta. Bul. 4 (n. ser.), p. 60. Alabama College Sta. Buls. 36 and 41.

SHEDDING OF BOLLS.¹

The shedding of bolls or "forms," or their death and drying while still attached to the plant, is very frequently a source of great loss to the cotton crop. The trouble has been long known, but one widely prevalent and disastrous form has been misunderstood. It is often confused with the work of the bollworm, with punctures made by some hemipterous insect, etc. That some of the shedding is due to the work of the bollworm is true, but the shedding referred to here is a purely physiological trouble.

During three years' observation in Alabama the author found this physiological form of shedding to be very serious. It occurs most frequently in extremes of either dry or wet weather, or during the change from one extreme to another. It may occur to some extent under normal climatic conditions, especially if the cotton plants are too thick, or the variety of cotton is one which develops a very large amount of fruit forms in proportion to the leaf surface.

During a normal period of growth the plants put out as many fruit forms as could be matured should the conditions favorable to growth continue. If a very dry period succeeds this, interfering with the supply of nutriment and moisture, there will occur a partial withholding of tissue-forming material and moisture at a very critical period in the life of the young "forms," and the tissues of the young fruit are forced into an unnaturally matured condition. The fruit, including the peduncle and often more or less of the surface tissue of the stem at its point of attachment, becomes first of a paler green color than the adjacent parts of the plant, so that a well-marked color line delimits the healthy from the unhealthy portion. In many cases the tissue is separated at this line, so that the fruit falls off completely or hangs by a few fibers to the stem. The early growing season may be exceptionally favorable for the development of a large plant with an abundance of young fruit, and if followed by even ordinarily normal conditions will result in a partial loss of this fruit. A long rainy season may also cause the young bolls or forms to fall, the soil being so saturated with water as to interfere with root absorption, and the assimilative activity of the leaves will also be disturbed.

The more or less complete separation of the tissues at the line of division between the healthy and dying portion depends upon the point of attachment of the fruit to the stem, and also to some extent upon the variety. In some cases the line of separation is apt to be clean cut, resembling the scar left by a falling leaf, especially when the peduncle stands at a strong angle from the supporting branch near its junction

¹ Alabama College Sta. Bul. 41.

with the stem or larger branch. If the point of attachment is at a somewhat greater distance from this junction and the peduncle much more inclined obliquely, the line of separation is apt to include from one-half to 1 inch of the surface tissue of the stem below the peduncle, and very frequently then the lower part of the dead surface tissue does not entirely separate and the boll usually remains clinging to the plant. In some varieties, especially the cluster varieties of cotton, the separation of the tissues does not take place so frequently, and the boll usually remains firmly fixed in position; but the dead part readily indicates the tissues involved.

The matured bolls do not form a separative layer of tissue when they mature, but remain fixed to the plant. The falling away of the dead immature bolls and forms, when it does occur, is a useful provision of nature, since the plant is left in better condition for the gathering of fruit which does mature. One great objection held by some to the cluster varieties of cotton is their tendency to hold the dead immature fruit. There is need of careful observations on this disease in order to throw light upon its treatment.

ANGULAR LEAF SPOT.

This disease is named from the dark angular spots which appear in the leaf. It is very widespread, but rarely appears to such an extent as to attract attention. Careful observation would probably reveal it in every cotton field during the growing season from May to July, and frequently later. The disease is first manifested by a watery appearance in definite areolate spots, which are bounded by the veinlets of the leaf. The spots are sometimes very numerous and frequently confluent. Often the disease follows one or more of the main ribs of the leaf, being bounded on either side by an irregularly zigzag line. In time the spots become blackish and then brown, and are frequently bordered by a blackish color where the disease has extended centrifugally. The dead spots in the leaf sometimes break out, leaving many perforations with ragged edges, somewhat as often results in "cotton leaf blight." The disease hastens the falling of the leaves.

In the very earliest appearance of the spots, when the watery condition is coming on, these spots swarm with bacteria. This suggested that it might be a bacterial disease. Cultures of the organism present were obtained and inoculations of healthy leaves were made at different times, but without producing the disease. It usually appears only in the older leaves which have passed their prime. It is quite likely that the bacteria present may easily start the trouble in such leaves, while they may be unable to affect the younger and healthy leaves. This may account for the failure of the inoculations. Sometimes, but rarely, it attacks all of the leaves on a plant. This suggests that such plants may be constitutionally weak from some unfavorable condition which renders them susceptible of attack. The trouble has not, however,

been sufficiently studied. There sometimes occur on the same plants bolls which present spots of the same watery appearance, which finally terminates in a rot and death. In this case the physiological weakness of the plant would naturally extend to the boll. A careful bacteriological study of the trouble in connection with physiological studies of the plant as related to different conditions of the soil, fertilizers, and meteorological conditions might throw more light on the disease.

Literature.—"Black rust of cotton," G. F. Atkinson, Bot. Gaz., 16 (1891), No. 3, p. 16; Alabama College Sta. Buls. 27 and 41.

FRENCHING.

This disease has been known for some time among planters in the middle and southern part of Alabama. Inquiries among planters by the author regarding the origin of this singular name for the disease did not elicit any information as to either the time when the name was applied or the meaning of the word in this connection. Judging from the significance of the verb of the same root, which means something foreign, and therefore in a later sense strange, unnatural, etc., it is intended to denote a strange or unnatural appearance of the cotton plant.

This disease is probably distributed over a large portion of the Southern cotton belt. The author knows of its occurrence in the State of Alabama at the following places: Mathews Station, Hope Hull, Allentown, Pike Road, Athens, Selma, and Montgomery. In 1892 specimens were received from Pine Bluff, Ark. The disease is sometimes confused with what is more properly known as variegated cotton, the foliage of which presents quite large angular areas of various colors, as red, white, and various shades of green on the same leaf, reminding one of a coleus plant. The author knows of several planters who thus confuse the variegated cotton with the disease frenching. Pammel¹ speaks of the term "frenching" being applied to variegated cotton in Texas, though he records nothing like this disease. It probably occurs in that State, however.

The first sign of the disease is usually a light yellowing of the lower leaves at the edge, or more commonly between the forks of the main ribs of the leaf. This yellowing of the leaf, which is sometimes nearly white and quite pronounced, is the result of a failing nutrition of the leaf, but the trouble is more serious than in the mosaic disease and progresses more rapidly. It begins at the edge of the leaves farthest from the large veins, and then progresses rapidly up the leaf between the ribs. The leaf then presents the yellow color in a radiate fashion parallel with the larger veins, and not in checkers, as in the mosaic disease. Quite early in the disease the leaf begins to brown at the points where the yellow first appeared, so that a brown color of the dead portions of

¹Texas Sta. Bul. 4.

the leaf follows quite closely behind the yellow. In this way there are three distinct colors, green, yellow, and brown, in parallel radiating bands. The brown and dead parts of the leaf soon break out, leaving the leaf quite ragged. The green color lies along the sides of the veins. This is bordered by the yellow, and the brown cuts a V-shaped figure in the yellow area, while the entire margin or only a part of it may also be brown and dead.

While the lower leaves are usually the first ones to be attacked, they do not go through all these changes of color before others are affected; but the general progress is from the lower leaves to those higher up on the plant. It is quite a common thing to see quite large plants with nearly all the leaves affected, the lower ones nearly dead while the upper ones are in the first stages of the disease. When the leaves are nearly dead, the tissues of the petiole at the junction of the branch mature, form a separative layer, and fall away. This may continue until all of the leaves of a plant fall off.

The author's first observations were made on plants about 1 foot in height, a short period before the first blooms appeared, in 1891. In May, 1892, at Mathews Station, he observed the disease in very young plants, only a few days old, and before the plumule was developed. The peculiar yellow color was well developed in the cotyledons. These plants were growing in the "gunpowder" soil of the black belt, and the season being at that time a little dry, the soil would frequently adhere in a hard lump about the roots of the plants. Taking advantage of this, a few of these very young plants which showed the disease in the cotyledons were taken up and transported to Auburn, Ala., a distance by rail of nearly 100 miles, where they were transplanted. The removal checked their growth for a few days, then growth set in and all external signs of the disease disappeared. But in the latter part of June, when the plants were almost 1 foot in height, they were severely attacked, and by the middle of July all of the leaves presented the striped appearance so peculiar and characteristic of the disease. The disease has never been known, except in this case, in the region about Auburn.

When the plant is old, these progressive changes in the color of the leaf are frequently distributed over many more courses on the leaf, following not only between the main four or five veins, but also the spaces between the primary branching of these veins. On plants possessing a mild type of the disease, some of the leaves may exhibit the yellow color in indefinite courses—now a few large yellow spots some distance from the edge, or a pale yellow occupying nearly one side of the leaf. But the disease is always sufficiently characterized—either by the usual relation of the different colors, or by the peculiar shade of yellow, or by both—for one who has once carefully observed the disease to easily detect it, except in some cases described later.

The sure test of the disease, however, is found by breaking or cutting

the stem of the plant. If it is "frenching" the tissues of the fibro-vascular system will appear light brown in color, the intensity of the color depending upon the virulence or stage of the attack. Planters say the heart is black. A microscopic examination shows the presence of a fungus, the threads of which sometimes completely fill some of the vascular ducts of the plant. The discoloration of the tissues is more pronounced in those ducts in which the fungus is located. Under the microscope the color of the tissues appears to be a brilliant yellow, unless quite old, when it is much darker and suffused with brown. The threads of the fungus are colorless when young, but become a bright yellow in age, and measure 2 to 4 μ in diameter. Minute spores, measuring 1 to 2 by 2 to 4 μ , are developed from the ends of the threads, and are found either attached to their points of origin or free within the ducts. Pure cultures were obtained and in all such cases the fungus proved to be a species of *Fusarium*.

The fungus enters the plant near the surface of the ground, or in the upper portions of the roots. As the threads increase they grow upward, and, reaching the branches and petioles of the leaves, grow out into their circulatory channels. This explains why the lower leaves are the first to be affected during the early period of the disease.

The plants sometimes put out new growth after losing all their leaves, and seem to a certain extent to recover from the disease. In many cases the upper part of the plant dies and the new growth comes from the latent buds and dwarfed branches near the ground.

These periods of convalescence may be followed by relapses several times during the season. The second attack often differs greatly from the first in external appearance, probably because the fungus is so well distributed all through the plant that its effect in attacking the new growth and increasing in the old is more rapid, thus not permitting the gradual sequence of color which takes place as described above. A few leaves sometimes show the characteristic sequence of color, but the leaf wilts, thus checking the color changes. The fruit is also affected and frequently undergoes decay when nearly ready to open, even on plants which do not seem to be very badly affected, or it frequently happens that in a light attack much of the fruit comes to maturity and opens in the normal way.

Unless complicated with some other disease the fungus does not advance with such rapidity into the roots. This probably explains why so many plants sometimes recover, the roots in favorable weather supplying constantly the necessary moisture and nutrition and furnishing material for the growth of the latent branches near the base. In sandy land the disease seems to progress much more rapidly, especially when the plant has attained considerable size. It then often happens that very few of the leaves show the gradual color changes described above, but on a hot or dry day suddenly wilt, a few of the leaves wilting on one day and more on the following, or sometimes all on the same day, the plant then soon dying.

This peculiarity of the disease by which the leaves suddenly wilt, in sandy land, is in external appearance very much like the root rot of cotton in Texas, but the etiology of the disease is very different.

Occasionally the plants on sandy land are also affected with the root gall nematode. Whenever cotton in frenching districts is infested by these worms, almost every plant is also affected by the organism of frenching. This is probably because the roots, being diseased by the worm, offer easy access to the fungus. But many of the plants that are frenching are not affected by the worms, even in sandy land. The two diseases are quite distinct, but when both attack a plant the trouble is far more serious. "Knotty swellings," such as are caused by this nematode, are reported by some planters to occur on the roots of cotton in the soil of the black belt. These are probably caused by the same nematode, but the author has never observed them on the cotton roots in the prairie soil, while he has many times seen them on cotton roots in sandy soil. That they do occur in the prairie soil on the roots of other plants is certain, since they have been found on the roots of tomatoes and lettuce.

Artificial cultures of the fungus.—Besides cultures for separation, which showed the fungus to be a species of *Fusarium*, cell cultures were made by using very thin sections of the diseased tissue, so that the microscope showed that the growth obtained originated from the fungus threads within the stem.

In artificial cultures spore formation takes place within fifteen or twenty hours from the time of starting the culture. The hyphæ in artificial cultures usually remained hyaline, only one case to the contrary being observed. This occurred in the case of some hyphæ in a bouillon culture which were left above the medium when transplanting some of the fungus from the bouillon culture. In a few days they had become the same color as the hyphæ found within the tissues. In artificial cultures frequently enlarged cells occur as intercalary cells of the hyphæ, which resemble gemmæ. Sometimes they occur at the end of a hypha, and in either case they may bear several flask-shaped basidia.

In artificial cultures the spores measure 2 to 5 by 4 to 40 μ , are continuous or 1 to 5 septate, colorless, faintly granular, frequently possessing one or more vacuoles. The very minute spores are narrowly oval, and as they increase in length become curved. The shorter ones usually have one end rounded, the other sharply pointed. The longer ones are usually pointed at both ends.

The fertile hyphæ, or basidia, as they are sometimes called, also vary greatly. The early ones, short and narrowly flask shaped, are supported on the main hypha by a narrow pedicel. Later they frequently increase in size and branch profusely. The formation of spores in artificial cultures reminds one of some species of *Gleosporium* and *Colletotrichum* where they are clustered about the end of the basidium. Frequently in this *Fusarium*, as in other species of this genus, the

fruiting hypha elongates as the spores are being borne and thus leaves the spores distributed along its course. On sterilized cotton bolls or Irish potatoes longer spores were developed than on agar or in bouillon.

Parallel cultures were made of a saprophytic *Fusarium* which occurs on cotton throughout the cotton belt and is also frequently found on the bolls of frenching cotton. The two seem to be specifically distinct. In the saprophytic species the spores are more strongly curved and the ends very long and slender. This distinction was maintained throughout several cultures. The name *Fusarium vasinfectum* was proposed for this fungus by the author.¹

Inoculations.—Experiments were made in August, 1892, to determine if the disease could be obtained by inoculations with pure cultures of the fungus. The *Fusarium* was considered not to be a sufficiently aggressive parasite to be able to make its way into the ducts of the circulatory system unaided. The fact that the "sore shin" fungus could disease the stems of young cotton plants, and that many of the plants recovered even after the ulcer reached the vascular system, suggested that possibly this fungus might prepare the way for the entrance of the *Fusarium*.

Several tests were made on growing plants that had been inoculated with the sore shin disease. In one experiment pure cultures of the *Fusarium* were inserted with success, one plant showing the external characteristics of the disease, and the fungus was found in the tissues when a microscopical examination was made. In another experiment plants affected with the frenching disease were placed in contact with some that were suffering from sore shin, the leaves of which in one case passed through the yellow color changes and then wilted.

The ducts of the stem also presented all the characteristics of the disease. The result was more satisfactory than that obtained from the inoculations from the pure culture of the *Fusarium*. This suggested the possibility that bacteria which are frequently found in the diseased tissues were the cause of the disease rather than the *Fusarium*. While positive assertions in favor of the *Fusarium* being the cause of the disease instead of bacteria can not properly be made, the evidence thus far in hand gives greater support to the former view. The *Fusarium* is invariably found in both cotton and okra affected with the disease. Bacteria are not always present except in later stages, for in quite a number of transplantings of diseased tissue to nutrient agar no bacteria were developed, while the *Fusarium* always appeared. Again, the same species of bacteria did not always appear, but sometimes one and then another. The season of 1892 being the last one of the author's stay in the South, it was impossible to pursue the investigation further. The separation of the bacteria and tests with each of the species present in the study of the etiology of the disease might be undertaken with advantage to clear up this point.

¹Alabama College Sta. Bul. 41.

Literature.—"Frenching of cotton," G. F. Atkinson, Agr. Jour., Montgomery, Ala., Aug., 1891. "Additional note on frenching of cotton," *ibid.*, Sept., 1891. "A season's observation on frenching of cotton," *ibid.*, Oct., 1891. Alabama College Sta. Bull. 41.

SORE SHIN; DAMPING OFF; SEEDLING ROT.

These are names applied to a very common disease which causes young plants to rot off partially or entirely at or near the surface of the ground. There seem to be several phases of the disease. Sometimes the tissues undergo a soft rot, which progresses very rapidly, and the early stages are not marked by any striking color characteristics. Another phase may progress rapidly or slowly and is usually quite well characterized by a reddish brown color which accompanies it. This phase is also characteristic in that it is usually manifested on one side of the stem in the form of an ulcer which gradually deepens until the vascular system is reached, when the life of the plant becomes really endangered. Even when this stage is reached, however, the plant may and does frequently recover.

This latter phase is characteristic of a very common disease of seedling cotton. It is called by the planters in many places "sore shin." Many planters say that "sore shin" is the result of a mechanical injury to the plant from a cut by the "scrape" used in cultivation. The term is sometimes applied to such injuries upon quite large stalks of cotton, but it should not be confused with the "sore shin" of seedlings which is caused by the parasitism of a fungus.

The fungus which is almost universally said to be responsible for the phenomena of "damping off" is *Pythium debaryanum*. While all cases of damping off are not by any means due to this *Pythium*, it is quite likely that many of the cases, of what above is termed a soft rot of seedlings, are due to it.

The fungus with which we are chiefly concerned here will be called "sore shin" fungus for convenience, for it is not well known at present what the species of fungus is, or even the genus, for from all of the artificial cultures yet obtained of it nothing but the mycelium and sclerotium stage has been obtained.

The diseased portion of the plant is just beneath the surface of the ground and presents an area of shrunken tissue of a dull brown or reddish color. The size of the shrunken area and the depth of the injury are proportionate to the serious condition of the ulcer, as it may be termed. If the injury remains confined to the superficial tissues the plant will usually recover. It does sometimes recover when the injury reaches the vascular tissue, but more frequently death results when the trouble has progressed thus far.

When the study of the trouble was first undertaken an examination of the diseased tissue showed the presence of several fungi. Besides the frequent occurrence of *Rhizopus nigricans* and saprophytic species of *Fusarium*, there were generally present in great numbers nonfruiting

threads of some fungus. This led to the supposition of their causal relation to the disease. The threads are 9 to 11 μ in diameter and the cells 100 to 200 μ in length. At first they are colorless and possess numerous vacuoles of varying sizes in the nearly homogenous protoplasm. Later they become brown in color. The branches extend obliquely from the parent thread, are somewhat narrower at their point of origin, and possess a septum usually 15 to 20 μ from the parent thread, giving a clavate form to this part of the branch which is continuous with the parent thread. Frequently the hyphæ are associated in strands, being woven and twisted together.

Pure cultures.—By placing affected seedlings on filter paper in a moist chamber there are developed in twenty-four to forty-eight hours numerous threads in a horizontal or procumbent position, which extend out for 1 to 3 centimeters over the paper, often not contaminated with other fungi. By transplanting a few of these threads, using a flamed platinum needle, into nutrient agar rendered acid by lactic acid (1 drop concentrated lactic acid to about 10 c. c. of nutrient agar), a pure culture of the fungus was obtained. A series of experiments was conducted to determine whether this fungus could really produce the disease and damp off the young plants.

The experiments showed that the fungus used in the inoculations was the cause of the disease produced at that season in the gardens and fields examined. Numerous cultures were made on Irish potatoes, cotton stalks, oak wood, cotton seed, and horse dung, the details of the cultures, as well as the experiments mentioned above, being published in Alabama Station Bulletin 41.

ANTHRACNOSE.

(*Colletotrichum gossypii* Southworth.)

The fungus causing anthracnose of cotton was described in 1890 by Miss Southworth,¹ according to whom the fungus was distributed in Ellis's North American Fungi,² under the name *Glæosporium carpigenum* Cooke. Type specimens of *G. carpigenum* were examined by her and found to be distinct from the cotton fungus. The presence of dark setæ among the basidia separates it from the genus *Glæosporium*. During the same summer the fungus was studied quite independently by the author, who only learned of Miss Southworth's study a short time before her publication appeared. His observations agreed with hers in placing it in the genus *Colletotrichum*. The result of the author's first study was read before the Association of American Agricultural Colleges and Experiment Stations at Champaign, Ill., November, 1890, and later published in the *Journal of Mycology*.³

The fungus is probably very widely distributed, but serious injury

¹ Jour. Mycol., Vol. VI, No. 3, 1890-91, p. 100.

² Ellis's North American Fungi, No. 2267, from Louisiana.

³ Jour. Mycol., Vol. VI, No. 4, 1890-91, p. 173.

seems to be confined to certain localities. The author has observed it at quite a number of places in Alabama, but only at Brundidge was any very serious injury to the fruit noted. At that place, in September, 1891, 10 to 50 per cent of the crop was destroyed on some plantations. In the vicinity of Auburn, while it occurs on other parts of the plant as well as the bolls, its greatest injury seems to be confined to the young plants.

Characters of the disease on the bolls.—The disease on the bolls originates in minute spots. These spots, when very small, are of a dull reddish color, and present minute shallow depressions of the surface



FIG. 5.—Anthracnose.

tissue. As these spots enlarge the tissue blackens until the development of the spores begins. These are developed in pustules, usually confluent, in the center of the nearly circular spot. With their development the color of the spot changes. If there are a few spores it becomes a dirty gray, or a bright pink if the spores are numerous. Where the spores are few in number, many of them stand out upon the surface on threads which have grown up through the tissue. The spores being colorless, a grayish cast is given to the dark background of diseased tissue. When the spores are developed in great numbers they are piled up into a considerable heap

and form a large confluent mass occupying the central portion of the spot. A pink pigment, given off by the spores, is produced here in such quantities that it can be seen. This gives the pink color to the spots. As the disease progresses the spots increase in size and the color bands which surround the spots move outward centrifugally. The outer band, which is the border of the spot, is dull reddish brown in color, and its outer limits are ill defined. Inside of this border is a blackish band, which borders the pink center. As the spots increase in size they frequently coalesce and form large, irregular, diseased areas, covering sometimes one-half the surface of the boll. If the fungus

attacks the bolls before they are full grown it arrests the growth of the tissues involved on that side of the boll, so that they are frequently inequilateral. It also induces a premature ripening of the tissues, when the bolls become dead, and dry in fixed forms. The natural separation of the carpels is prevented. The boll either remains closed, or, as is more frequently the case, the carpels separate at the apex only, so that the boll remains partially open. In either case the fungus penetrates to the lint in many cases, and is often found upon it in great abundance. In such cases the seed is likely to be included in the attack. Several saprophytic fungi are accompaniments of the disease in these final stages.

Affecting the stem.—So far as the author has observed the fungus does not produce any characteristic injury to the stem of well-developed plants which is noticeable, but it is frequently found in injured parts of the stem, and on the scars formed by falling leaves, where the dead tissue of the scar, especially in humid weather, invites its development.

The fungus sometimes seriously affects the stems of seedling cotton, attacking the stem at the surface of the ground or just below, and causing the plant to wither and die, much as if it damped off. The tissue reddens and shrinks frequently in longitudinal lines. The macroscopic appearances of the injury are usually quite different from those occasioned by the "sore shin" fungus. The stem is not apt to present the well-defined ulcer, or diseased depression, which is so characteristic of the injury from the latter. Seedlings are probably frequently diseased in this way from the spores which are lodged in the lint of the seed at the time of planting. In cultures of young plants in sterilized soil annoyance was sometimes caused by the development of the fungus under circumstances such that they could have been diseased in no other way than from spores which remained attached to the seed. Several times during the winter of 1892 and 1893 cotton seed from Alabama was planted in the forcing houses and botanical conservatory of Cornell University, and the fungus appeared sufficiently to damp off and disease several seedlings. This seed, which was gathered in the autumn of 1892, afforded a good illustration of the vitality of the fungus. Some of these same seed were planted during the winter of 1893-94 and the fungus appeared upon the stems of the young seedling. In all cases where the seed were scalded before planting the fungus did not appear. The anthracnose spores were not found in the lint in these experiments, and it may be some as yet unknown reproductive body accompanying the seed which will retain its vitality for such a long time. The anthracnose spores, however, have been found to germinate when taken from the diseased bolls after five months. In trials of some from the same bolls at seven months the spores failed to grow. It is quite possible that the mycelium may rest in the tissues of the seed, as in the case of the bean anthracnose, *Colletotrichum lindemuthianum*, and probably scalding the seed would not kill the mycelium within the tissues without also killing the seed, although this treatment might partially prevent the disease.

Affecting the leaves.—The anthracnose is frequently found upon the leaves, it being more liable to develop in sickly leaves or injured places than to attack healthy ones. From the partial saprophytic habit of the fungus, otherwise diseased or injured leaves as well as stems provide a nidus for the propagation and transport of the fungus from the seedlings through the growing season to the bolls.

The seed leaves, or cotyledons, however, suffer from a characteristic injury. While the seed is germinating, the spores caught in the tangle of lint still adhering to the seed coats germinate and attack the fleshy cotyledons as they are slipping from the coats. The fungus attacks the edges of the cotyledons and destroys an irregular area bordering the middle portion. The cotyledons, being quite fleshy and succulent, form a suitable place for the development of spores, and the diseased area is marked by the bright pink or roseate tint so characteristic of its profuse development on the fruit.

The degree of success which attends the throwing off of the seed coats by the cotyledons during germination probably bears a very close relation to their susceptibility to disease. After the young root has emerged from the seed coat, or "hull," if the conditions are such as to cause the hull to dry and remain so, it is cast off by the cotyledons with difficulty and sometimes not at all. Frequently the hull clings to the extremities of the cotyledons, holding them firmly, while their bases are exposed to the light and consequently take on a green, healthy color. The edges of the cotyledons thus held acquire a sickly yellow color, and frequently the effort to extricate themselves results in some abrasion of the tissue. In either case the edges of the cotyledons, under such unnatural conditions, are an easy prey to the anthracnose spores which fall on them from the tangle of the lint still on the seed coat. Such cotyledons are sometimes attacked by a *Fusarium*, the spores of which also produce a pink pigment, and the fungus can then only be differentiated from the anthracnose by the use of the microscope.

Young plants have been inoculated by sowing the spores on the cotyledons. This at first suggested the possibility of the fungus using this mode of entrance to the plant as a means of spreading through the tissues, to be prepared for the final attack on the fruit and other parts of the plant, much as is known to be the case in *Cystopus candidus* and certain of the Ustilagineæ. Examination of the stem of affected plants fails to disclose the mycelium in all parts of the plant, and there is no evidence that the anthracnose travels along through the plant from the young stem or cotyledons to the bolls and leaves. Circumstantial evidence is very strong, even, that this is not the case. At all stages of the growing season the fungus produces spores very soon after germination takes place, so that crops of spores are developed in rapid succession where conditions for growth are present. Furthermore, the fungus is not in any appreciable degree an obligate

parasite, but is markedly saprophytic at times. There is a reasonable possibility that the crop of spores produced on the diseased young stems or cotyledons will soon find an opportunity for growth and production of another crop of spores at some injured point on a leaf, or upon the partly dying tissue of leaf scars. When the fungus obtains a good hold in the tissue of the stem it does serious injury, which is not the case with the smuts in the stems of the cereals.

Characters of the fungus.—The spores are oblong, sometimes rounded at both ends, but usually rather sharply pointed at the base. There is usually a broad, shallow constriction at the middle, so that the ends of the spore are greater in diameter than the middle. The protoplasm is distinctly granular, and one or more vacuoles are present. The spores measure 4.5 to 9 by 15 to 20 μ . Where they are produced on green or decaying bolls or other succulent parts of the plant they are usually associated in distinct acervuli or heaps, which are 100 to 150 μ in diameter. The acervuli are composed of numerous spores, with the fertile hyphæ from which they are developed and the underlying stroma within the tissues of the plant. The fertile hyphæ are of two kinds. The most numerous ones are short, colorless threads, arising from the stroma, and standing parallel, and very closely crowded together. They are usually called basidia. The second kind are long, dark, olive-colored, septate setæ, which are characteristic of the genus *Colletotrichum*. In this species they bear spores, which is quite an unusual thing in the genus. The setæ are straight, curved, or flexous, simple or rarely branched. They measure 100 to 150 μ in length. Their distal ends are nearly hyaline, and the spores borne upon them are often obovate, the base being rather sharp pointed. They seem to arise later in the development of the pustule after the ordinary basidia are developed, when parts of the stroma are becoming dark colored. They arise from the dark parts of the stroma or from rudimentary sclerotia. Many times in young acervuli the setæ are not developed, and if this condition alone were known the fungus would be referred to the genus *Gleosporium*.

Artificial cultures.—Several artificial cultures were made to trace the development of the fungus. In some cases the nutrient medium used was agar peptone broth with and without an infusion of cotton leaves.

The spores germinate quite freely under favorable circumstances in from four to ten hours. At the time of germination or prior to it, frequently one or two transverse septa are observed in the spore, dividing it into two or three cells. Several germ tubes may be produced from a single spore. The mycelial threads begin to branch immediately, and are somewhat flexous in their course. From all parts of the mycelium short fertile branches soon arise of one, two, or three cells length, which resemble the basidia and bear spores. Sometimes these fertile branches or basidia arise directly from the spore. In the solid medium the spores from a single basidium, when not crowded by the basidia and other

spores, are clustered around the end, each succeeding spore pushing the one which has just become free to one side. The sharply pointed basal end of the spore favors this. After several days there is a beautiful crown of spores clustered at the end of the basidium, all lying parallel to each other. Spores are sometimes produced within eighteen hours from the time of sowing.

Besides the production of spores, certain branches, either remote from or near the center of growth, produce at their ends peculiar enlarged cells, olive brown in color and varying in outline, but always of greater diameter than the hyphæ which bear them. These bodies frequently produce immediately a normal hypha resembling the others of the mycelium. This in turn may soon produce another bud, or may grow to a considerable length and produce basidia and spores, or develop spores soon after its origin from the bud like an ordinary basidium. In many cases the gemma immediately begins to bud in an irregular manner, producing cells similar in color, but very closely compacted together into an irregularly oval or elongated or flattened imperfect sclerotium. After one or two weeks' growth a large number of these gemmæ and imperfect sclerotia are developed near the center of growth. At the same time, the basidia have become very numerous at this point, arising from the mycelium or by the branching of older ones, and the mass of spores assumes a roseate tint. Cultures were also started in pure water and in weak nutrient medium. In water the germ tubes, when once or twice the length of the spore, almost invariably produced gemmæ. If these developed other tubes it was only to give rise to other gemmæ. In no case at that time were spores produced nor any appreciable length of mycelium. In the weak nutrient medium the gemmæ were produced freely; also a number of hyphæ produced spores. While the vegetative growth exceeded that of the spores sown in water, there was but little compared with that of spores sown in a rich medium, and the spores did not live so long. These gemmæ are sometimes spoken of as secondary spores. They are not secondary spores in the usual acceptance of that term. They do not become freed from the mycelium except by accident or by the dying of the thread to which they are attached, in which case they are more properly gemmæ. Their frequent later development into compound gemmæ by budding would strengthen this view, and indicate that they are rudimentary sclerotia, or perhaps presage the development of pycnidial or ascigerous stages, as yet unknown in this genus.

In cultures on nutrient agar the author has never observed setæ to develop in such numbers nor so perfectly as they do naturally on the host. But by pouring a small quantity of agar on scorched lint in a culture tube and then inoculating this medium with spores the setæ developed profusely.

During October, 1893, cultures of the fungus were started again, this time from material from Mississippi, for the purpose of noting the form

and growth characters of the colonies in plate cultures. The dilutions were poured in Petrie dishes and kept near a north window, where it was rather cool, especially during the night. The temperature ran up during the day to 70° or 75° F. The development of the colonies was rather regular in contour, though a marked periodicity of growth was induced by the change of temperature from night to day, resulting in the formation of concentric rings upon the colonies. The web of fungus threads was rather thin over the entire colony, and radiating lines figured by the threads were plainly discernible even when the colonies were old. The first germ tubes did not branch profusely in the early growth, so that directly around the center of growth the colony was quite open, the threads not covering the entire space, and the light was transmitted through this part much more readily than through the portions of the colony surrounding it. The fungus was transferred to bean stems, and later to sterilized vetch stems. From this last culture another set of dilution cultures was started in April. They were kept at a warmer temperature, and while the growth of the colonies was similar to those grown at a lower temperature, the size of the colonies was greater and all the characters were shown on a greater scale. Some of the spores were quite small, so that only one or two germ tubes were developed at one end. Since the threads grew much more rapidly at the higher temperature and branching was not frequent or rapid at the early stage of development, the young colonies in these cases presented elongated, thin, and scarcely discernible tufts issuing from the point of growth. In other cases, where several germ tubes arose from all sides, numbers of these tufts extended in all directions from the center of growth. As growth progressed and the colonies increased in size, the periphery became more and more compact by the greater profusion in the branching. From the small spores where there were but few germ tubes, and these from one side of the spore, the colonies were unsymmetrical, or one-sided, and the radiating threads formed well-marked, fan-shaped tufts. These fan-shaped tufts are also frequently developed in the symmetrical colonies where the original lines of growth from the spore are not sufficient in number to close up the periphery of the colony. This is more marked where the colonies are more numerous, as in the first and second dilutions, while usually in the third dilution, according to the method used, there were but few colonies, the nutrient medium being not so soon consumed, and there being more room for the advance of the colonies, they are more apt to close up at the periphery and form quite compact colonies. The unsymmetrical or eccentric colonies in this case form at first several beautiful fan-shaped tufts, which soon unite and form a reniform colony, later to be closed at the sinus, though the colony would still remain unsymmetric.

Literature.—"Anthracnose of cotton," Southworth, Jour. Mycol., vol. 6 (1890-91), pp. 100-105. "Anthracnose of cotton," G. F. Atkinson, Jour. Mycol., 6 (1890-91), pp. 173-178. Alabama College Sta. Bul. 41.

ROOT ROT OF COTTON (OZONIUM).

A preliminary account of the root rot of cotton was published by Pammel in December, 1888.¹ A fuller account of the investigations appeared in the following November.² The following account is an extract of the latter, supplemented by the results of the author's own investigations.

The disease is a true rot caused by one of the higher fungi, but nothing as yet has been found except the rhizomorphic and a sclerotia-like condition, so that the affinities of the fungus are still unknown. The fungus was published by Pammel provisionally as *Ozonium auricomum* Link, but it is quite likely that it is not identical with that species. Certainly it is not identical with several specimens which occur in some of the European exsiccatae. It will here be spoken of simply as "*Ozonium*."

There is a general belief among planters that certain soils only harbor the disease. The investigations showed, however, that nearly all classes of soil are more or less subject to it. Planters suffer most from the disease in the central black prairie region of Texas. Its northern boundary is the Red River as far east as Paris, Tex., extending in a southwesterly direction to San Antonio and thence westward. The counties of Montague, Wise, Parker, and Hamilton are the western boundary in the north. A white rotten limestone, often cropping out, underlies the entire region. The soil of these black waxy prairie lands is very retentive of moisture, which is a condition favorable to the development of the fungus. The moisture is especially abundant when the limestone comes near the surface of the soil. The cotton frequently dies from the disease on the limestone ridges and slopes when none is affected in other parts of the field. For the discussion of the various theories which have been advanced to explain the cause of the disease before it was shown to be due to the parasitism of a fungus, reference should be made to Pammel's work.

Characters of the disease.—The first indication manifested by the cotton plants of the activity of the fungus is the sudden wilting of one or more plants. This is usually first noticed in the latter part of June and early in July, though the time varies with the locality. Planters sometimes associate the dying of cotton with the appearance of flowers and the bolls, but from the condition of fields early in July it seems that it makes its appearance much earlier in the season. R. D. Blackshear, of Navasota, Tex., has reported plants dead from the trouble as early as May 6, and certainly quite young plants are affected with it. The fungus has been seen on plants only 6 inches high. The sudden wilting of a considerable number of plants does not occur, however, until near the middle of June or later. The wilting of a single plant here or there in the field might be overlooked or be attributed to some

¹ Texas Sta. Bul. 4.² Texas Sta. Bul. 7.

other cause. This explains why from general observation the disease is thought to appear first at a later period. From a single stalk which dies in May or June the disease may spread so that areas of considerable extent will be affected by the close of the season. The dead patches have no definite boundaries, but extend in all directions through the field, the black streaks and patches formed by the dead plants occasionally containing a few green plants. In passing through the belt where the disease is prevalent a striking contrast is observed between the areas made black by the dead plants, everywhere so conspicuous in the fields, and the interspersed green areas of apparently healthy plants. The suddenness with which plants die is governed somewhat by the atmospheric and soil conditions. Planters frequently say that dry weather checks the disease. During the dry weather in August, 1888, few plants were dying. In the latter part of August the rains set in, and then during intervals of sunshine large numbers of plants wilted. In June and July, 1889, it was again noticed that more plants gave the external evidence of disease after a rainy day which was followed by warm sunshine than during several days of dry weather.

Healthy plants are frequently found close to diseased ones even late in the season, but it does not follow that such green plants are not affected with the disease, as has been shown to be the case by examination. For example, eight plants were found growing in a cluster, two of which had wilted, and in each case the taproot was covered by the mycelium. In two of the green plants the taproot contained an abundance of the fungus, and the plants would probably have wilted in a very few days. In two other cases a small amount of the fungus was found on the roots, while only a single one at that time was apparently exempt.



FIG. 6.—Root rot.

Every plant which presents the pathological conditions above described possesses the fungus on the roots, if we add to the sudden wilting of the plant the characteristic shrunk areas of the roots. Under the article on frencing it will be seen that sometimes this disease causes the plants to wilt suddenly under atmospheric conditions similar to those which are most favorable to the sudden wilting of the plants from the Ozonium.

If the roots of plants just dead from the disease be examined, frequently there are small "wart-like" bodies on the surface, which very often occupy the lenticels of the root. These are probably the same as the sclerotia-like bodies, which are described farther on. Plants which have not yet succumbed to the disease, but which are affected, show the presence of the fungus on the root, sometimes in considerable quantity, so that it appears as if the root, or a portion of it, were covered with a whitish mold. The white threads gradually assume a brown color, beginning in the older portions. The taproot is usually the first to be attacked, and the point which the fungus first invests is somewhere near the surface of the ground. It does not begin at the tip or near the tip of the root, and in many cases the lower portion of the root is free from the fungus, at least in the early stages. In cross sections of the diseased roots the characteristic threads of the fungus are seen to extend into the medullary rays and into the vessels. The threads within the tissues of the root do not become brown in color, and there are not the peculiar branching setæ, but the identity of the threads with the fungus upon the surface can be determined by the direct continuation of the superficial threads with the internal ones.

The fungus derives its nourishment from the living substances of the root, and also in its physiological processes sets up certain fermentations which kill the affected portions, causing partial decomposition, which results in the shrinking of the tissues and the formation of quite extensive depressed areas. The borders of these depressions show at first a red discoloration, which ultimately becomes brown. Near the surface of the soil an enlargement frequently is formed in which elaborated materials are apparently stored during the progress of the disease. From these enlargements new roots are frequently developed as the lower roots are placed under contribution to the parasite. These help, in favorable weather, to prolong the life of the plant, but are usually not sufficiently developed to prevent the collapse of the plant when the older roots give way. When the roots become seriously injured, root absorption of material from the soil becomes so diminished that it is not equal to transpiration from the large leaf surface, and the plant wilts.

In the affected areas the disease spreads from year to year in a centrifugal manner, the fungus making its way through the soil from plant to plant.

The lint of the diseased cotton is injured, the fibers are wider, and the spirals are fewer and more uneven than in lint from healthy plants.

Some have supposed that the disease could be transmitted through the seed, but experiments have shown that this is not the case.

Morphology of the fungus.—The threads which are found upon the surface of the roots are usually associated in strands which course over the surface of the root irregularly and branch quite frequently. The internal threads are sometimes associated in parallel layers, but are not formed into distinct strands like those upon the surface. The cells are hyaline, usually short, and of a greater diameter than the separate superficial threads or those upon the surface of the strands. The threads which compose the strands are usually of a greater diameter in the inside of the strand and smaller upon the surface. From the surface of the strands there are numerous free threads which stand out at various angles. Many of them are quite peculiar and characteristic of this fungus. They terminate in a long slender point, and frequently possess opposite or verticillate branches of the same character. No fruiting condition in the form of conidia has as yet been determined, nor any form analagous to the fruit body of any known fungus.

The *Ozonium auricomum* Link, of Europe, is very different from the above fungus, though it is similar in habit in many cases and produces diseases of the roots of various plants. The space is too limited here for a discussion of the diseases due to this fungus, but mention should be made of the supposed complemental or fruiting form which has been reported in a number of cases in Europe. The complemental fruiting form is given in many cases by different authors as a very distinct fungus, which is evidence that very much weight can not be given to the specific determination of these root fungi by the rhizomorphic form only, unless there seems to be some very characteristic features, as in the case of the Texas *Ozonium*, which mark it very clearly. The European *Ozonium* is said by Schroeter¹ to be the undeveloped condition of *Coprinus radians* Penzig², of *C. intermedius* Winter³ and Saccardo⁴, of *Trametes odorata* Holuby⁵, of *Agaricus diliquescens*. This would seem to show that the European *Ozonium* was at least the rhizomorphic form of one of the Hymenomycetes. Pammel is inclined to think that the Texas *Ozonium* is the undeveloped form of some Pyrenomycetous fungus, probably being influenced in forming this opinion by the discovery of the frequent association of a fungus in the roots of the diseased cotton and sweet potatoes which possesses blackish rotund bodies that resemble the perithecia of some Pyrenomycetes, and also by a doubtful artificial culture which he obtained by washing the threads of the *Ozonium*. The cultures obtained from this were not in any way like those of the fungus as it appears in its natural habitat,

¹ Kryptogamen Flora von Schlesien, Bd. III, 1st Heft, Pilze, 1889, p. 519.

² Sui rapporti genetici tra *Ozonium* et *Coprinus*, Nuovo Giorn. Bot. Ital., XII, pp. 132-143.

³ Die Pilze, in Rabenhorst's Kryptogamen Flora von Deutschland, I, p. 405.

⁴ Saccardo, Sylloge Fung., VI, p. 345.

⁵ Zur Kryptogamen Flora von Ns. Podhrad, Oest. Bot. Ztschr., 1874, No. 10.

but it was suggested that this might be due to the influence of the artificial medium. The pure cultures obtained by the author later show that this could not be the case. Pammel himself did not place much confidence in the results from his supposed cultures of the *Ozonium*. But this makes little difference from the standpoint of the treatment of the disease.

Treatment.—The results of experiments at the Texas Station¹ show that the disease can not be controlled by any application to the soil at present known. Rotation of crops seems to be the only method which will keep the fungus in check. There are, however, a large number of other plants upon which the fungus can grow readily. If plants which are susceptible to attacks from the *Ozonium* are grown year after year on the same ground the soil becomes, after awhile, so thoroughly infected with the fungus that the crop will not grow to any extent. Corn, sorghum, millet, wheat, oats, and other members of the grass family are suggested as desirable crops to grow in rotation with susceptible plants. Some suggest a rotation which will bring cotton or a susceptible crop into cultivation on infected soil not oftener than once in three or four years.

Other plants subject to the disease—Pammel names the following plants as subject to attacks from the *Ozonium*, and from which the disease may be communicated to cotton grown in the same soil: All nursery stock except species of the genus *Prunus*, apple trees, Russian and paper mulberry, China berry, Japanese persimmon grafted on native persimmon, elm, basswood, and silver maple. Of these the China berry and paper mulberry trees suffer most severely. In August, 1888, the roots of a number of living China berry trees were observed to be covered with the fungus, and in the following year they were found to be dead, and the disease had spread to some young paper mulberry trees in the neighborhood.

Old and dying trees frequently develop suckers. At Anna a number of paper mulberry trees nearly dead produced hundreds of suckers from 6 inches to 2 feet high which covered an area of several rods. The suckers were wilting in large numbers and many were dead. Specimens of the pear from Burnet County had the fungus on the roots, but the trees had been dead for some time and it was thought that the fungus worked only as a saprophyte on these trees. When young apple trees are affected with the fungus the leaves suddenly wilt and turn black and in a short time the trees perish. In older trees death is more gradual. They have a sickly appearance several years prior to death, bear a heavy crop of fruit, and then die. The *Ozonium* disease of apple trees must not be confounded with the trouble brought about by the presence of aphides (*Schizoneura lanigera*) on the roots, which develop, as the result of injury, irregular knots on the roots. Sometimes both the aphides and the *Ozonium* are found upon the same root.

¹Texas Sta. Bul. 7.

Weeds affected by the fungus.—The common sida (*Sida spinosa*) is very commonly attacked by the *Ozonium* in infected fields. Even in fields well cared for by the planter this weed may be found in limited numbers. Frequently in such cases as well as where the weed is more abundant it is found to be attacked by the disease. This would be expected, at least since other plants are known to be subject to the attacks of the fungus, because the sida belongs to the same family as the cotton plant. The fact that this weed is subject to the attacks of the fungus and that it is a very widely distributed and common weed throughout the cotton belt is one difficulty in the way of success from the rotation of crops. The ragweed and cocklebur and some other *Compositæ* were found to be affected by the fungus. In all the cases observed the attack upon these plants seemed to follow some injury of a mechanical nature. There was no doubt that the fungus caused the death of the plants in question, but it was considered doubtful if they initiated the trouble.

In orchards and nurseries all diseased plants should be dug up and burned. Care should be exercised in the purchase of nursery stock to see that the roots are perfectly healthy. In the use of sweet potatoes for seed great care should also be taken, for in the use of affected potatoes or the planting of affected nursery stock the fungus may be transplanted to soils in which formerly the fungus was not present.

. To the above-mentioned plants which are subject to the *Ozonium* should be added alfalfa.¹

ARTIFICIAL CULTURES OF THE OZONIUM.²

During the summer of 1891 the author made several attempts to secure pure cultures of this fungus from material received from Texas. The affected roots were placed on sand in moist chambers, and the fungus strands grew in several instances from 4 to 6 inches out over the surface of the sand. Portions of these strands were transferred to nutrient media and failed to grow.

In 1892 the work was again undertaken, the author being supplied once or twice a week with fresh material. Each root before shipment was carefully wrapped separately with moist paper, retaining a small portion of the earth with it, several of such roots making a single package. Before receiving the specimens the author prepared several moist chambers in the following manner: A layer of sand about one-half inch deep was placed in a glass vessel and covered with four thicknesses of filter paper; the sand and paper were then moistened with distilled water and the cover placed in position. The moist chambers were sterilized in an oven at a temperature of 140° C. for an hour or two for two successive days. On the arrival of the roots they were carefully unwrapped, the earth removed, the roots washed with distilled water and cut into pieces 5 cm. long, and placed horizontally on filter paper, four or five sections in each chamber. In two or three

¹ Texas Sta. Bul. 22.

² Bot. Gaz. 18 (1893), No. 1, pp. 16-19.

days the strands of *Ozonium* could be seen growing out over the filter paper for a distance of 4 to 6 cm. Sterilized glass slides were now placed at the advancing end of the strands, and upon these were placed small sections of cotton roots which had been previously boiled and then steamed for several hours to sterilize them thoroughly. Sections of such roots about 3 cm. long were placed upon the glass slide so as to come in contact with the fungus. At the same time similar sections of sterilized cotton roots were placed in test tubes in moist sand and partially immersed in distilled water. In twenty-four to forty-eight hours the *Ozonium* strands would take hold of the bait placed before them, so that the section of root could be transferred bodily to prepared culture tubes. The end containing the growth was placed in contact with the sterilized root already in the tube.

Sterilized sweet potatoes were also used in test tubes as media for transplanting. The fungus grew rather slowly, but out of 75 baits which were promising 4 or 5 proved to be pure. From these, cultures were multiplied to the number of 50. Great difficulty was encountered to prevent the contamination by several species of fungi and bacteria. The *Ozonium* on artificial media, such as sterilized cotton roots or sweet potatoes, grows readily after once securing a firm hold, and possesses all the other characteristics observable in a natural condition upon the cotton roots. Being free from obstruction and hindrances which it encounters in nature, the growth is perhaps more compact, numerous strands uniting to form a brown weft, but the peculiar strands were present as well as the characteristic and branched setæ.

Since the first transplantings the author has become more familiar with the habits of the fungus, and has found it an easy matter to cultivate it with certainty and in profusion.

The *Ozonium* grew steadily over the sterilized cotton roots in a broad weft, the threads of which radiated from the point of infection. The line of advance is rather irregular, due to the unequal growth of the filaments. The weft is white for several days, when numerous branches arise on the free surface, giving it a woolly appearance. Later, prominent strands appear, lying in irregular parallels. About this time the color changes to a light yellowish brown, the characteristic color of the older phases of the fungus.

After considerable growth has been made sclerotia-like bodies appear. They are from very small to 3 mm. in diameter, whitish and woolly, finally becoming of the same color as the filaments of the fungus. Internally the sclerotia are hyaline, and the cell walls are very thin. The outer portion is composed of threads similar to those of the strands.

The development of the sclerotia was checked, and the experiment was begun anew in the winter of 1892-93. Having no cotton roots on which to grow the fungus, apple-tree root, sweet potatoes, and horse dung were substituted as culture media. The fungus grew quite well, but failed to produce any sclerotia.

The structure of the strands and threads conformed essentially with Pammel's description. Some of the threads which form the early stages of the strands are much larger than others, and are strongly constricted at the septa. Branches of various sizes put out from the parent thread, and in their growth closely invest it in a sinuous and irregular spiral. Other branches put out from the first in the manner just described, the new branches following the general direction of the strand. The branching of the strands depends to a certain extent upon the branching of the primary threads. The formation of the strands resembles the formation of the cortical layer of some of the species of *Batrachospermum* or the covering of the axial filament of species of *Lemanea*.

In artificial cultures, near the ends of some threads were observed swellings resembling oögonia. Sometimes the enlarged end of the hypha is brought in contact with these oögonia-like bodies, as though to fertilize them, but nothing resembling the fertilized oögonium was observed by the author. The bodies here described quickly disintegrate. At first this phenomenon was thought to be preliminary to the formation of some sort of fruiting body, but it seems more likely that the protoplasm, developing certain acids having a strong affinity for water, imbibes large quantities of water, and the branches become abnormally swollen before their disintegration.

Besides the *Ozonium* in several cases another fungus was present, which has been supposed by some to be another stage of the one under discussion. In the case of this one the mycelium is dark in color, and dark perithecia-like bodies have been noticed by Pammel and the author, and the author noticed in some cultures a peculiar form of budding; but while the fungus was carried through several cultures at different times, none of the supposed fruit bodies produced spores, so that the exact position of the fungus is mere speculation. That it is different from the *Ozonium* there is little doubt, since in artificial cultures of two complementary forms of the same fungus there should be some indication in one of them of the affinity. There was, however, throughout the entire series of cultures of both fungi no form or appearance which indicated the least resemblance that could be taken as indicating an affinity between the two.

During the cultures many saprophytic fungi came under the author's observation which were associated with the *Ozonium* on the roots in the soil. Some of these were obtained as pure cultures on the baits which were set for the *Ozonium*. Some of these were sent to A. P. Morgan, Preston, Hamilton County, Ohio, for determination. The fungi noted in this connection were as follows: *Edocephalum echinulatum* Thaxter, *Sporotrichum chlorinum* Link, *Penicillium candidum* Link, *P. glaucum* Link, *P. duclauxi* Delacr., *Mucor mucedo* Linn., *Rhizopus nigricans* Ehr., *Licea lindheimeri* Berk?, *Verticillium rexianum* Sacc., a species of *Eurotium*, several species of *Fusarium* which were very common, the fungus described in the paragraph on damping off, several nonfruiting forms, a pink yeast, and several species of bacteria.

It would be very interesting, from a scientific standpoint, to know the perfect or fruiting form of this *Ozonium* on cotton roots. If a pure culture could be again obtained, and then grown on a large number of sterilized cotton roots all massed together in some soil in a place where moisture conditions would be favorable, in time this form might be developed. The failure to obtain this form in the above trials is attributed to the fact that all the cultures were carried on on too small a scale, so that there was not a sufficient amount of roots in one place, and the moisture conditions were subject to too great variations, so that in the course of a few weeks the culture would become partially dry or completely so. The environment should be such that proper conditions of moisture could be sustained for a year or more. The author's study of the fungus thus far, however, leads to the belief that when this form is discovered it will prove to belong to some genus of the Hymenomycetes.

COTTON-LEAF BLIGHT.

(*Sphaarella gossypina* Atkinson.)

The cotton leaf blight is a very common disease of the cotton plant, but it very rarely becomes serious. It usually attacks only the older leaves or those which have become weakened by physiological disturbances affecting the nutrition or assimilation of the leaves. The fungus was first known in what is called the imperfect form, or conidial stage. This form of it was described by Cooke as *Cercospora gossypina*. The diseased areas on the leaf are in the form of rounded, irregular spots, which possess a dull reddish border surrounding a brownish or whitish central area. In the central area the fungus is located. The intercellular mycelium consists of irregular, branched, septate threads, which here and there near the surface develop a tuberculate stroma that gives rise to tufts of emergent hyphæ, brownish in color and several times septate. Long, slender, terete, septate, hyaline conidia are borne at the ends of the hyphæ. After one hypha has developed a conidium this becomes freed and the hypha grows out at one side of the end and bears another conidium. This process is usually repeated several times, so that each hypha bears several conidia, and the hypha presents a toothed or zigzag form at the fruit-bearing end, each tooth or angle representing the place by a scar where a conidium had grown. These conidia germinate by the production of a germ tube at any or all of the usually numerous cells. These penetrate the tissue of fresh leaves and spread the disease. The spots first appear as minute reddish dots, which increase in size centrifugally, and finally the center becomes brownish, leaving the red border which is characteristic of the spots. As the spots become old the central portion frequently becomes broken out, leaving the leaves with a perforated and ragged appearance.

This fungus quite frequently attacks the leaves of cotton affected with the mosaic disease. In some phases of the mosaic disease it is the commonest fungus on the leaves, and as the leaves die they become

curled in various ways, and during favorable weather, as during rains in the hot summer time, a great profusion of hyphæ and conidia are developed. The brown hyphæ give a blackish appearance to the leaf, while the colorless conidia form a whitish covering to portions of it. The conidia and hyphæ, under these circumstances, are very long. On such leaves the perfect, or *Sphærella*, stage of the fungus is quite likely to be developed. These have been found in several parts of Alabama, and they undoubtedly occur in all the cotton-producing States. This stage of the fungus (*Sphærella gossypina*) was first described in a bulletin of the Torrey Botanical Club.¹ The perithecia are ovate and nearly black, and partly immersed in the tissue of the leaf, the ostium and the apical portion projecting through the epidermis. They measure 60 to 70 μ . The asci vary from clavate to lanceolate or subcylindrical, measuring 40 to 50 by 8 to 10 μ . They are eight-spored, the spores being elliptical or nearly fusoid, and slightly constricted at the single septum, which divides the spore into two unequal cells.



FIG. 7.—Areolate mildew.

Literature.—Cooke, *Grevillea* 12 (1883), p. 31. "Cotton-leaf blight," F. Lamson-Scribner, U. S. Dept. Agr. Rpt. 1887, p. 355. "*Sphærella gossypina*," etc., G. F. Atkinson, Torr. Bot. Club, Bul. 18 (1891), No. 10. Alabama College Sta. Buls. 27, 36, and 41. Bot. Gaz., 16 (1891), p. 62.

AREOLATE MILDEW OF COTTON.

(*Ramularia areola* Atkinson.)

This mildew is confined to definite areolate portions of the leaf, the areas being limited by the veinlets. The clusters of short hyphæ which project through the epidermis to the outside of the leaf and the numbers of conidia borne upon them give a mildewed or frosted appearance

¹No. 10, 1891.

to the spots. The hyphæ are colorless, usually simple, though sometimes branched, and divided into short cells. The conidia are short oblong, one to three septate, the ends being usually abruptly pointed. They are borne singly or in chains, and the successive places on the hyphæ where they were attached show a toothed surface.

The fungus has been found by the author several times in different parts of Alabama, and specimens have been received from Mississippi. It is not of very common appearance, and the indications are that it is not harmful, though it is sometimes produced in considerable profusion. It probably occurs in other States also. It was first discovered in the autumn of 1889.¹

When viewed from above the spots present a light yellowish tint in the green leaf. Viewed by transmitted light the spots are paler and permit the light to come through more freely than through the other parts of the leaf. The hyphæ are usually more numerous on the underside of the leaf and sometimes only upon this side, but they may be borne upon both sides even on the same spot. It is not likely to become of any serious importance.

Literature.—"A new *Ramularia* on cotton," *Bot. Gaz.*, 15 (1890), p. 166. Alabama College Sta. Bul. 41.

COTTON-BOLL ROT.

(*Bacillus gossypinus* Stedman.)

This disease was first described by J. M. Stedman.² It affects the bolls, seed, and lint. Affected bolls were first received from Baldwin County, Ala., in August, 1893. The bolls were in a rotten condition and contained insects which were determined as *Epurua astiva*, and *Carpophilus mutilatus*, beetles known in the Southern States, Mexico, Central and South America, and having the habit of feeding upon decaying and injured fruit of all kinds, and sometimes found sucking the sap from wounds in trees. They were found common in cotton bolls and in heaps of decaying cotton seed. They were thus regarded as not having any connection with the cause of the disease.

Saprophytic fungi and in some cases the anthracnose of cotton were found, but in bolls that were only slightly diseased no fungus was observed. Pure cultures of the bacteria inside the closed bolls were made by the plate method, and cultivations were started on gelatin and agar.

In gelatin in four days the bacteria clouded the entire mass, giving it a greenish color. In agar the growth produced a milky cloud along the entire track of the needle path and over the surface of the agar as a more or less white, semitransparent glossy growth. Bolls on healthy cotton plants were inoculated with the bacteria from these pure cultures, and in all cases the disease appeared. Other bolls punctured with a sterile needle remained healthy except in one case, where the

¹*Bot. Gaz.*, 15 (1890), p. 166.

²Alabama College Sta. Bul. 55.

decay produced was different from that characteristic of the disease. This rot is said to originate within the boll, and is not apparent until the contents of the boll are decayed, when the carpels show signs of the disease in places. It first begins as a small, dark-brown area involving the young seed at the point near the peduncle. If it begins some time before the maturity of the boll, the entire boll will rot and not open; but it may begin so late that only a few seed and a small portion of the lint are affected, while the carpels separate and the lint may be exposed and gathered.

Stedman discusses the question of the probable means of entrance of the bacillus into the interior of the boll. The suggestion that the germs may in the ground in some unexplained way make their entrance in the root and travel up the stem to the boll is made, and also the question of entering the young ovary at flowering time, when the germs may be distributed to the ovaries by the agency of insects. The possibility of the germs being in the seed at the time of planting is also suggested, and plans for experiments to determine the manner of infection are proposed. The organisms would not induce pathological conditions when introduced to any other part of the plant, although in some cases they were able to live for some time. The disease is chiefly confined to the middle and top crop, first manifesting itself early in August.

The organism is a short straight bacillus, truncate at the ends, with slightly rounded corners, 1.5μ to 0.75μ . It is usually solitary, sometimes in pairs, and occasionally in chains of three to four. It stains readily with the usual aniline colors, is aerobic, nonliquefying, motile, and forms spores, though the latter are not described.

The problem of the entrance of the organism to the bolls should be investigated, together with the relation of the plant to soil and climatic conditions in connection with the disease; also its possible connection with the disease called "frenching" should be taken into account. In this disease the organism, as we know, travels up the stem through the vascular ducts, and aside from the foliage characteristics, which are usually quite marked, many of the bolls are affected, and the rot here begins in the interior of the boll at the same point as in the cotton-boll rot. It should also be borne in mind that when the bolls are within a few weeks of maturity they are in one sense a form of nutrient medium for even saprophytic fungi and bacteria which are introduced into them, so that too much reliance should not be placed upon the results of the inoculation of the bolls through needle punctures.

ROOT GALLS OF COTTON.

(*Heterodera radiculicola* (Greef.) Muell.)

The roots of cotton are sometimes affected with a disease caused by a nematode worm, which, living in the tissues, causes abnormal growths termed "galls." This is also a very common affection of many other

plants, and especially in gardens throughout the South and in green-houses in the North. The worm is, in fact, quite generally distributed over the world.

A related species, *Heterodera schachtii* Schmidt, is also quite common in Europe, affecting especially the roots of sugar beets, and its life history has been well worked out by Strubell.¹ *Heterodera radiculicola* was made the subject of investigation by Mueller,² though he left some important points undetermined.

In the autumn of 1889 a paper on the injuries produced by this worm was published by the United States Department of Agriculture.³

Almost immediately following this paper was one by the writer⁴ (1889) dealing with the life history and metamorphoses of this nematode and the injuries produced by it upon the plants in the vicinity of Auburn, Ala. In the course of this work some points in the life history of the worm were more fully elucidated.

The females are of a dull white or yellow color, with irregularly oval bodies from 0.25 mm. to 0.5 mm. in diameter. They are usually quite easily differentiated when mature from the tissue of the plant in which they

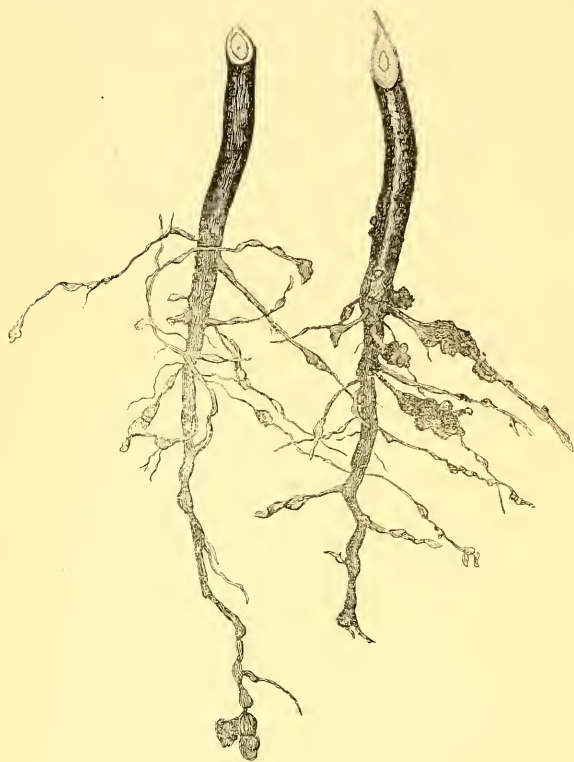


FIG. 8.—Root galls.

lie when the gall is broken open. Usually the unaided eye can also distinguish the head end projecting as a minute point on one side,

¹ Untersuchungen über den Bau und die Entwicklung des Rüben-nematoden, *Heterodera schachtii* Schmidt (Bibliotheca Zoologica. Original Abhandlungen aus dem Gesamtgebiete der Zoologie, R. Leuckhart und C. Chun. Heft 2), Cassel, 1888.

² Mittheilungen über unseren Kulturpflanzen schädliche, das Geschlecht *Heterodera* bildenden Würmer, Landw. Jahrb., XIII, 1884.

³ The root-knot disease of the peach, orange, and other plants in Florida, J. C. Neal. (U. S. Dept. Agr., Div. Ent. Bul. 20.)

⁴ Nematode root galls, a preliminary report upon the life history and metamorphoses of a root-gall nematode, etc. Ala. College Sta. Bul. 9.

giving to the object the appearance of a minute gourd or "crooked-neck squash," or of a minute inflated bladder. They can be well seen with the aid of a small hand glass. The cephalic portion of the body is cylindrical, the end being rounded; the mouth is terminal, and opens caudad into the œsophagus which leads to the intestine. Lying within the mouth is a spear, slender and long-pointed at the cephalic extremity, and ending in a three-lobed knob at the caudal end. It is capable of extension, being moved by pairs of muscles attached directly to it. In the males the caudal end of the spear is supported by six lamellæ, the ends of which form the cephalic end of the head and fit around the spear. The œsophagus begins at the base of the spear. The cephalic portion is a long, slender, tortuous channel, which appears as a dark line, reaching to near the swollen part of the cyst. The middle portion of the œsophagus is an ovoid or ellipsoidal transparent, muscular bulb, which has a fibrillate structure, the fibrillæ radiating from the center. The caudal portion of the œsophagus connects with the intestine. In the gravid females this is difficult to see, since at this stage the mass of fat globules renders the body cavity too opaque.

Were it not for a slight movement of the apparatus just described as the spear is thrust back and forth, or slight movements of the head, there would be nothing to suggest what we ordinarily consider a sign of life. Occasionally while the cyst is under microscopic examination the spear is thrust slowly out at the mouth and then drawn back. At the same time the cephalic part of the œsophagus connected with it is also moved. Sometimes the apparatus slides far enough so that the tortuous portion of the œsophagus is straightened and the bulb is moved a little forward and backward. Sometimes there appears also a slight lateral motion of the head, a sudden, "jerky" motion. This is probably from force of habit, for in the larval stage movement from place to place is accomplished by a constantly changing, tortuous motion of the body. Mueller (loc. cit.) speaks of an expansion and contraction of the middle part of the œsophagus which he has observed. By this means nutriment from the plant is sucked into the œsophagus and thence passed to the intestine. Within the vesicular portion of the body, frequently more or less obscured by the mass of fat globules, are the two long genital tubes, which are coiled and considerably longer than the body. The genital tubes are paired, and near the caudal portion of the body they unite into a common tube, which extends to the exit, the vulva. The genital tubes, though nearly cylindrical, are composed of four parts. The anterior or free ends, including about one-third the length, are the ovaries. The receptaculum seminis is near the center, and is connected with the ovaries by the oviduct and with the vulva by the uterus.

The mature male is nearly cylindrical, 1 mm. to 1.5 mm. in length and about 43 μ broad near the middle. The body is a little less in diameter at the caudal end, and the cephalic half tapers very slightly to the head end, which is about half the diameter of the middle of the body.

The body is beautifully marked by prominent transverse striæ, broader and much more distinct than in the larval stage. The excretory canal opens on the ventral side a little caudad to the muscular bulb. The caudal end of the body is curved, and near it are the two spicules at the opening of the cloaca. The generative organ is paired. The long slender testes, lying on either side of the intestine, reach by their free cephalic ends to about the middle portion of the body. Some little distance from the caudal end of the body they unite into a common canal, which itself, near the spicules, unites with the intestine to form the cloaca. The spermatozoa are spherical. The cellular structure of the testes resembles to a certain extent that of the ovaries. The cells are polyhedral from mutual pressure. In living males the spherical spermatozoa are easily seen at or near the common passage, but they are developed in the caudal ends of the testes.

By boiling infested potatoes so that the worms could be removed easily from the softened tissues without cutting or crushing them it was found that it toughened the tissues of the animals and made the cellular structure of the testes, by coagulation of the albuminous substances, very distinct.

DEVELOPMENT AND METAMORPHOSES.

Eggs.—The young ova are developed in great numbers in the ovaries, and when full grown the genital tubes are crowded for nearly their entire length. They are very plastic; when free are spherical, but crowded in the ovaries are polygonal. Each one presents a large nucleus and distinct nucleolus. When quite young they are nearly hyaline and transparent. Near the cephalic end of the ovaries there are several layers of them because they are quite small, but as they grow in size and pass down the ovaries to the oviduct and receptaculum seminis they become elongated and a single one completely fills the transverse diameter of the duct, and its length is twice the diameter. The mature egg is 80 μ to 100 μ long. The ends are rounded, and the form is somewhat curved so that it resembles a bean. The protoplasm in the young and transparent egg gradually becomes granular, and in the mature eggs the coarse granules and fat globules are so numerous that the egg becomes opaque and the nucleus is seen with difficulty.

After the eggs are fertilized in the receptaculum seminis they move on toward the uterus and vulva, but it is very rare that they escape from the body of the cyst, since that is usually inclosed on all sides by the surrounding tissue. The uterus becomes ruptured and the eggs become free within the body cavity. Segmentation of the egg frequently begins before the egg escapes from the uterus. The eggs may be found in several stages of segmentation while still within the uterus. The first division is usually such that the egg is divided into two unequal cells, though the difference is not very great. From this time the segmentation is somewhat unequal. These two primary unequal

cells represent the mother cells of two different groups of cells. The larger cell divides more rapidly and forms small cells which completely surround the group of larger cells that result from the slower segmentation of the smaller primary cell. The growing over of these smaller cells proceeds first down the convex side of the egg. This ectoderm layer of cells folds over the opposite end of the embryo, the endoderm cells. Thus the prostom is upon the ventral side of the egg—that is, the concave side—because the ectoderm cells on the concave side of the egg have grown but little. If at this stage we turn the egg so that we are looking directly at the concave side, the ectoderm cells will be in a boat-shaped mass, and within this are the endoderm cells. The prostom now begins to close by the growth and increase of the cells at the margin. This closure takes place more rapidly at the caudal end and advances toward the cephalic end, so that there is finally only a small opening through the ectoderm near the cephalic end on the ventral side. This at last becomes completely closed. Invagination now takes place at the cephalic end, and the mouth and œsophagus are developed. Some of these phases can be seen while the embryo is still of the same length as the egg, but it soon begins to elongate and becomes more slender, and at the same time coils around within the egg. Eventually it is coiled three or four times. When it reaches this stage it remains a day or two within the eggshell, when by writhing and twisting the egg membrane is ruptured and the embryo escapes. In doing so it molts for the first time.

Larval stage.—The larva is 300 μ to 400 μ long; it tapers gently to the cephalic end and gradually into the pointed caudal end. In this form it resembles what are called “vinegar eels.” The larvæ at the time of hatching are inclosed usually by the surrounding tissue in which the female cyst was inclosed. They make their escape either by the decay and disintegration of the tissues or by battering a place of escape with the use of their spear. With the spear they also now gain an entrance into fresh and uninjured portions of the roots. The plant not being able to expel the invader bends its energies to the repair of the injury, and the result is the formation of a gall, by the increase of the cells at the injured part, all of which lessens the energies of the plant normally directed to the production of leaf and fruit. The larvæ wander through the tissue for a time, when they molt again and pass into the cystic state.

Cystic state.—The larvæ locate at various depths in the tissues, and the body now begins to enlarge or “swell” up, except at the ends. Almost before any increase in the size of the body takes place it becomes rigid so far as any voluntary motion of any considerable extent is concerned. It may be twisted or turned in very curious forms when this rigidity comes upon it. The enlargement begins close behind the muscular bulb of the œsophagus, and for a little time this part of the body is a little larger than the caudal part. Very soon the enlargement

takes place all along the body as far as the anus at the hyaline portion, some little distance from the pointed end of the tail. The cyst is at first irregularly spindle-shaped, then clavate with a sharply pointed process, the tail, at the larger end. Up to this time it is very difficult to distinguish the sexes, but from this point they strongly diverge. The female cyst continues to enlarge until it reaches the vesicular form which it possesses at maturity, while the male undergoes a second transformation and returns to the thread-like or anguillula form.

Transformation of the male.—The body of the male at this time is of the same size as that of the cyst, very stout in proportion to its length. The first sign of the transformation is the slipping of the head from this end of the cyst. At the same time the thick body begins to elongate, narrow, and double up within the cyst wall. This is the third molt, and while it is undergoing this change it molts again, making four in all. The male continues to elongate until it is coiled three, four, or more times within the cyst, according to the length of the latter, which retains perfectly its former shape. During this transformation the sexual organs of the male have matured. It now breaks through the wall of the cyst and travels through the tissues until it reaches a female, when fertilization takes place, after which the male soon dies.

A life cycle of the worm is completed in about one month. Therefore in favorable seasons there would be seven or eight successive generations in a single year. When we consider the number of eggs each female is capable of producing (from 100 to 200), it will be seen that the worms must multiply with startling rapidity. The periods of transformation of different individuals do not altogether coincide, so that at almost any season we may find worms in all stages of development.

The injuries produced by the presence of the worm cause distortions of the tissue elements, and in many cases so devitalize the tissues that putrefactive organisms set to work and produce extensive diseased areas. The large amount of nutriment taken also by the roots in the development of the galls lessens the product of the plant. The greatest injury to cotton, however, seems to appear when the disease is accompanied with the "frenching" organism (see p. 290). Great care should be used in transferring rooted plants which are liable to be affected by the nematode from one place to another.

Occasionally some males were found which showed but a single testis. Since *Heterodera schachtii* possesses but a single testis, it might be well to inquire whether that species were also present and whether they are associated in the same roots in some cases or whether there is a variation in *H. radiculicola* in the possession of paired and single testes. This, however, must be left to future investigators.

THE INSECTS WHICH AFFECT THE COTTON PLANT IN THE UNITED STATES.

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The cultivation of cotton in the United States has gone through a curious change with regard to the depredations of insects. Not very long ago, according to statistics published by this Department, the average annual loss to the cotton growers from the work of a single species of insect amounted to \$15,000,000, while in such seasons as that of 1868 and that of 1873 the loss far exceeded this amount. This insect was the so-called cotton caterpillar, or cotton army worm, or chenille, or cotton-leaf worm (the larva of *Aletia argillacea* Hübn.). Down to the year 1881 the damage done by this insect so far exceeded that inflicted by any other species that other forms had received but little consideration.

With the rapid extension of cotton culture in Texas, however, the so-called bollworm (the larva of *Heliothis armiger* Hübn.) became a very prominent factor in the cultivation of the crop. This insect had always been known as an enemy of cotton in the other States, but the damage which it accomplished was greatly inferior to that of the cotton-leaf worm. Texas, however, speedily became noted for bollworm damage, and as early as 1879 this insect was recognized as the chief depredator on cotton.

The subject of the cotton worm attracted very considerable attention at an early date. Southern newspapers and magazines contained many articles, of which those by Dr. D. B. Gorham, Mr. Thomas Affleck, Dr. D. L. Phares, and Mr. William Jones are the most important. Mr. Townend Glover, the first entomologist to this Department, investigated the subject of the cotton worm in the fifties, and, in fact, the literature of the subject increased very rapidly after the destructive year 1847.

After the close of the civil war a series of cotton-worm years followed, unfortunately just at the period when the loss of a part of the crop meant more to the people of the South than had been the case at any previous time. This attracted investigation to the subject, and it was not long before the use of paris green upon the crop was suggested, probably in the first place by Prof. C. V. Riley, at that time entomologist to the State of Missouri. It was later advocated by Mr. Glover, representing this Department, and circulars were sent out from

the Department in the year 1873, urging the use of this arsenical poison upon the crop.

After the conclusion of the work of the United States Entomological Commission on the Migratory Locust, or "Hateful Grasshopper" of the West, the most prominent and destructive insect in the country demanding investigation seemed to be the cotton worm. Under appropriations from Congress the investigation of this insect was carried out by the United States Entomological Commission and the Division of Entomology of this Department, working independently.¹

At just about the time when the commission finished its labors upon this insect the insect itself ceased to be a serious enemy to cotton. Since that season the damage which it has done has been comparatively small, and at the present time the cotton worm is not feared by planters. That this state of affairs is due in part to the work of the official investigations can not be doubted, but to claim that it is due entirely to this work would not be justified. The widely disseminated knowledge of the life history of the insect and the consequent general adoption of the plan of early poisoning (i. e., before the destructive third generation of the caterpillars has made its appearance) in the more southern portions of the cotton belt have had much to do with the recent comparative immunity; but aside from this, the cotton worm is undoubtedly much less abundant and destructive than it was fifteen years ago, and as a consequence it no longer holds the first position among the insect enemies of the cotton crop.

With the bollworm, however, we find a different state of affairs. This insect, as will be shown in a later portion of this article, does not depend upon cotton alone for its existence. It feeds upon many different plants. The cultural methods in vogue all through the South are peculiarly favorable to its development, and it is, moreover, a hardy insect, with comparatively few natural enemies. Further, it feeds for the greater part of its existence protected by some portion of the plant which it infests, and in a solitary way, so that it is not subject to the contagious diseases which are so fatal to many injurious insects of gregarious habit. This latter cause also operates against successful treatment, and the result is that bollworm damage has not diminished, but in fact has increased in many portions of our cotton-growing territory.

¹The results of these investigations are contained in three volumes: The first is a 144-page pamphlet published as Bul. No. 3 of the Entomological Commission, January 28, 1880; the second a 500-page volume issued by the Department of Agriculture and entitled "Report upon Cotton Insects," etc., by J. Henry Comstock, submitted November, 1879; the third, the "Fourth Report of the United States Entomological Commission," by C. V. Riley, published in 1885, a bulky volume of about 600 pages, illustrated by 64 plates and numerous text figures. Although its last report was not published until 1885, the work of the commission was practically completed with the year 1881. Copies of this report may still be obtained through Members of Congress.

As shown above, the bollworm was incidentally studied during the Government investigation of the cotton worm. Its life history was completely made out, and fairly satisfactory remedies were discovered and displayed in Comstock's report on cotton insects and in the Fourth Report of the Entomological Commission. No general adoption of these remedies resulted, however, and as a general thing planters either undertook no remedial work whatsoever, or relied upon such exploded remedies as the use of trap lanterns and poisoned bait. As a result of the continued damage done by this species, Congress provided, in the appropriation bill for the fiscal year 1890-91, for a supplementary investigation by the Division of Entomology of this Department. At that time considerable attention was being given to the subject of contagious diseases of insects, and the Entomologist was instructed to conduct a thorough series of experiments in the direction of the practical use of some such disease as applied to this insect. The work of a season in the field by an assistant in the division, F. W. Mally, who was helped by Dr. A. R. Booth, of Vicksburg, and by Mr. Nathan Banks, of the office force, resulted in the publication of Bulletin 24 of the division, in which it is shown that the best dependence of the cotton grower is upon the remedies recommended in the Fourth Report of the Entomological Commission, and that nothing practical is to be hoped for in the way of the encouragement of any disease. Congress renewed the appropriation the following year, and Mr. Mally continued his work. The results are summarized in Bulletin 29 of the division, which is entitled, "Report on the Bollworm of Cotton," and which was published in the spring of 1893. It is a pamphlet of 73 pages, and contains a number of new but comparatively unimportant facts relative to the economy of the insect and the details of the experimental work. No new remedies of value were brought out.

Aside from the cotton worm and the bollworm, the cotton plant can not be said to suffer seriously from the attacks of insects. Cutworms sometimes damage the young plants in the beginning of the season; plant lice occasionally cause the withering of the terminal leaves (also usually early in the season); there are several bugs which sting the young bolls, although never to any serious extent; grasshoppers sometimes "rag" the leaves in Texas, and there are several leaf-feeding caterpillars which appear later in the season, and in reality do little but remove the superabundant foliage and expose the bolls to the sun, causing earlier ripening, and consequently a beneficial rather than an injurious effect. We occasionally learn of a case of local and temporary damage by one or another of several species of insects, such as the garden webworm, which injured young cotton growing in proximity to garden crops in Texas, Arkansas, and Indian Territory a few years ago; but these cases are rare, and do not deserve extended consideration.

A serious exception to this general statement may in the future be

found in *Anthonomus grandis*, a Mexican weevil which damages cotton bolls. This insect, down to the close of the season of 1894, was known to us only through a few specimens collected upon cotton bolls in Mexico some ten years since by Dr. Edward Palmer. During 1894, however, we learned that the species had made its appearance in the State of Texas. It works in a peculiarly injurious manner, utterly destroying many bolls. The life history of the species was carefully investigated during 1895, and the writer has published two circulars of information, which have been widely distributed among cotton planters.¹

After this brief summary it will be evident that the subject of insects injurious to cotton in the United States will be most conveniently handled under four main headings—(1) the cotton worm, (2) the bollworm, (3) the Mexican cotton-boll weevil, and (4) other cotton insects.

THE COTTON WORM, OR COTTON CATERPILLAR.

(*Aletia argillacea* Hübn.)

GENERAL APPEARANCE, HABITS, AND LIFE HISTORY.

This insect is perfectly familiar to all cotton growers. The slender, bluish-green caterpillar with small black spots, and often with black stripes down its back, which loops when it walks and feeds voraciously on both upper and under surfaces of the cotton leaf, is to be found in cotton fields in the Gulf States all through the summer. It is generally not noticed in the early part of the season on account of its insignificant numbers. Later, through the ragging of the leaves, it becomes noticeable, and in seasons of abundance the plant is entirely defoliated. Farther north the insect makes its appearance at a later date in the season, and there the caterpillars are not the offspring of hibernating moths, but of the moths of the first or second generation, which have developed in more southern cotton fields and have flown north with the prevailing southern winds. Late in the season moths of the fourth or fifth generation fly far to the north, frequently making their appearance in numbers about electric lights in Canada. There is no absolute evidence of any other food plant than cotton, although many entomologists have surmised that the species has a northern food plant. The specimens seen in Canada have, however, in all probability flown north from cotton fields in the Carolinas, and perhaps even farther south.

The egg.—The egg is bluish green in color and of a different shade from that of the leaf, so that it can be rather readily distinguished. It is flattened-convex in shape, with many parallel longitudinal ridges converging at the center above. It is found usually on the underside of the leaves and as a general thing toward the top of the plant. In the neighborhood of 500 eggs are laid by each female, sometimes several upon one leaf, but never in clusters. The eggs are laid at night, since the moth is a night flyer. The duration of the egg state varies somewhat, according to the season. In midsummer the larva hatches in

¹ U. S. Dept. Agr., Div. of Ent. Circ. 6 and 14, n. ser.

from three to four days after the egg is laid, but in spring and autumn this period is very considerably lengthened.

The larva.—After hatching from the egg, the young larva feeds at first upon the underside of the leaf, devouring simply the lower parenchyma and not piercing through to the upper side until after the first molt. At first the larva is pale yellow in color, soon becoming greenish. The dark spots become more or less conspicuous after the first molt, and the characteristic markings, as shown in the figure, make their first appearance. After the second molt these markings become more conspicuous, and the insect takes on a distinctly greenish color, the black along the back varying among different individuals in its intensity. Before reaching full growth the caterpillar sheds its skin five times, and the duration of the caterpillar stage is from one to three weeks. Early in the season the green color appears to predominate, while toward the fall the blackish caterpillars are more abundant, although at any time during the season green and dark worms are seen together. Although the normal food of the caterpillar is the leaves, it will frequently gnaw the tender twigs and will even damage the bolls by eating into them in spots. This, however, generally occurs only when the worms are present in exceptional numbers and the supply of leaves becomes exhausted. We have referred to the fact that the caterpillar is a looper, i. e., that it walks by bringing its hind prop legs up to the true legs, causing its back to arch up in a loop. Like the true loopers, or measuring worms, it has the habit of jerking itself some little distance when disturbed, and when it falls it usually supports itself by a silken thread. It is something of a cannibal, and when other food fails, or even rarely when leaves are abundant, it will feed upon smaller and feebler individuals of its own kind. In spite of its comparatively small size and slender

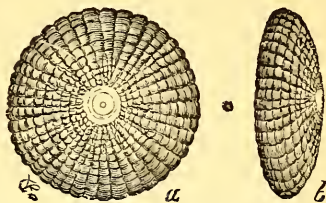


FIG. 9.—Egg of cotton worm moth: *a*, top view; *b*, side view—greatly enlarged (from Fourth Report U. S. Entomological Commission).

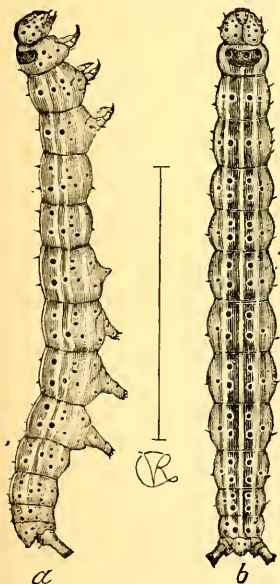


FIG. 10.—Cotton caterpillar: *a*, from side, *b*, from above—twice natural size (from Fourth Report U. S. Entomological Commission).

form, this larva is, in fact, very voracious, and when occurring in numbers the ruin which it accomplishes is complete.

The chrysalis or pupa.—The caterpillar, having become full grown, never enters the ground to transform, although many planters have believed that this is the manner in which the insect passes the winter.

It spins a light silken web, forming an imperfect cocoon, usually within a folded leaf. It is frequently seen hanging quite naked upon the plant, but in such cases the leaf in which it was originally spun has been eaten away by other caterpillars. Its color is at first green, but in the course of an hour or so it changes to brown. The insect remains in this condition for a period varying from one week to thirty days.

The adult insect.—The perfect insect or imago of the cotton caterpillar is a rather small moth of an olive-gray color, sometimes with a some-

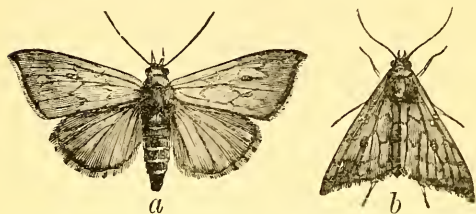


FIG. 11.—Cotton worm moth: *a*, with wings expanded in flight; *b*, wings closed, at rest—natural size (after Riley).

what purplish luster. Its wings expand from $1\frac{1}{2}$ to $1\frac{1}{2}$ inches. The markings of the wings are indicated in the figure. The moth is a night flyer and hides during the day, starting up and flying with a swift, somewhat darting motion when disturbed.

After sunset it takes wing and flies about, laying its eggs or searching for food. It feeds, in fact, rather extensively, frequenting neighboring flowering plants and also the nectar glands of the leaves of cotton. Fruit, as it ripens, also attracts these moths, and is frequently seriously injured by them. The tongue or proboscis of the moth is curiously modified and fitted for piercing the skin and tissues of ripe fruit, as is shown in the figure. It is said that they are able to puncture hard green pears, the effect of the puncture being a discoloration of the skin for some distance around. The female begins to lay her eggs in from two to four days after leaving the chrysalis, and each individual lays from 300 to 600 eggs. With five consecutive and rapidly developed generations the occasionally extraordinary numbers of the late broods are not to be wondered at.

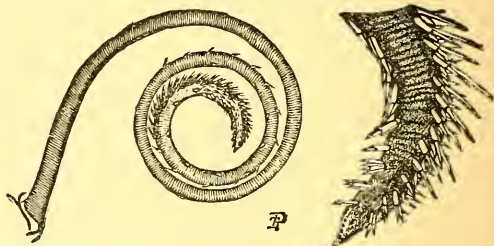


FIG. 12.—Proboscis of cotton worm moth—enlarged; tip at right still more enlarged (from Comstock's report on cotton insects).

Number of broods or generations.—The observations of Mr. Schwarz in South Texas in 1879 show that at least seven, and probably even more, generations are produced there. Fully as many probably develop in Florida. The general belief in the South up to the time of the beginning of the cotton-worm investigation was that there were three generations only, since three "crops" of worms only were customarily observed. The early generations, however, were overlooked on account of their small numbers, and, in fact, in the northern portions of the cotton belt, the general idea was correct enough, since northward-flying moths in general do not oviposit in fields in this region until

comparatively late in the season. The moths hibernate, only in the extreme southern portions of the cotton belt, as will be shown in the next section, and begin to lay their eggs as early as March, or perhaps even earlier, in South Texas and Florida. Two generations are rapidly developed, and then, in these localities, a confusion of generations commences on account of the retardation of development in certain individuals and acceleration in certain others. Moths from the end of March on are constantly flying out from these points and, carried by the prevailing southerly winds, settle in more northern fields and stock a certain number of plants with eggs. Moths developing from caterpillars hatching from these eggs in turn stock the fields in which they have developed with a greater number of eggs, and a certain proportion of them fly farther north. In this way there is a progressive development all through the cotton belt and a somewhat varying number of generations in different localities. Under certain conditions, however, such as the early development of a very large brood in the far South, so many moths may be developed that there is a nearly simultaneous stocking of a very extensive region.

The importance of ascertaining the early presence of the worms, although in small numbers, from a remedial point of view is very great, and since it was conclusively shown that worms may be found in the fields in the Gulf States long before the so-called "first crop," planters have looked for them more carefully, and doubtless in many cases possibly severe injury has been prevented by the poisoning of early worms.

The moths of the last generation in seasons of cotton-worm abundance frequently make their appearance in numbers far North. The moth is a very strong flyer, and, aided by the wind, has been known to occur abundantly in Canada, and has been observed in numbers far out at sea. During September it has been known to do very considerable injury to peaches in Kansas and to ruin acres of cantaloupes as far north as Racine, Wis.

Method of passing the winter.—The greatest difficulty was found in settling the question as to the manner in which this insect passes the winter, but it has finally been established that over the more northern portion of the cotton belt the species dies out every year, while in the more southern portions the moth hibernates and remains torpid in sheltered situations. There must also have been occasionally an ingress of moths from outside of the United States, say from the West Indies

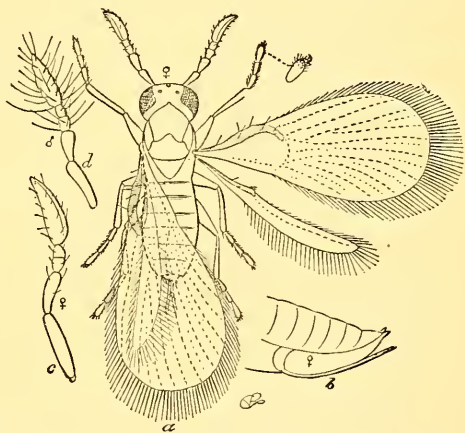


FIG. 13.—Cotton worm egg parasite (*Trichogramma pretiosa*): a, adult female, greatly enlarged; b, ovipositor; c, female antenna; d, male antenna, still more enlarged (from Fourth Report U. S. Entomological Commission).

or from Mexico or Central America. It was undoubtedly in this way that the species was first introduced into the United States, and such immigrations were probably of frequent occurrence down to comparatively recent years. Professor Riley, writing in 1882, concluded that there is nothing more fully established than that the moth hibernates principally under the shelter of rank wire grass in the more heavily timbered portions of the South, and that these moths begin laying on the ratoon cotton when it is only an inch or so high. Only the exceptional few survive, and this survival seems to be more common in the western part of the cotton belt than in the Atlantic States.

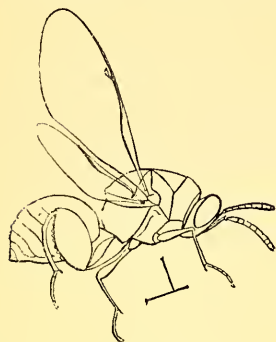


FIG. 14.—*Chalcis flavipes*, an important parasite of the cotton caterpillar (from Fourth Report U. S. Entomological Commission).

PARASITES AND NATURAL ENEMIES.

In the report by Professor Comstock, published in 1880, and in the Fourth Report of the United States Entomological Commission much space is devoted to the subject of the natural enemies and parasites of the cotton worm. They are very numerous, and without their aid the worms must have done infinitely more damage than they have accomplished; but, practically speaking, we need devote no space to their detailed consideration, as they can not be practically handled. Their increase can not be encouraged beyond the enforcement of general laws against the killing of insectivorous birds. A few of the most important of the predaceous and parasitic insects are shown in the accompanying figures. The little egg parasite, *Trichogramma pretiosa* (fig. 13), is one of the most important. Mr. Hubbard has recorded the fact that in Florida this one parasite almost entirely annihilated the fifth brood. At the beginning of the fourth brood about half of the eggs were destroyed by this insect. Of the eggs laid by the fourth-brood-moths, from 75 per cent to 90 per cent were parasitized, while of the eggs of the fifth brood the proportion destroyed by the parasite exceeded 90 per cent, and out of the sixth brood careful estimates show that but 3 or 4 eggs out of 100 escaped. The external parasite of the caterpillar *Euplectrus comstockii* (fig. 15), is also another abundant parasite, while the other insects figured take almost as important parts in limiting the increase of the worm. As far back as 1847 Dr. D. B. Gorham found that nearly all of the chrysalids of the last brood of worms were destroyed by *Pimpla conquisitor* (fig. 16). From this fact he argued that the fields must be restocked by moths flying up from the South, and perhaps from the West Indies. It is a very curious fact that some twenty-five

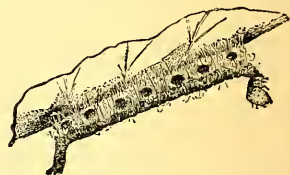


FIG. 15.—Skin of cotton caterpillar attached to the underside of cotton leaf by silk spun about the pupæ of *Euplectrus comstockii*—natural size (from Fourth Report U. S. Entomological Commission).

years later Mr. A. R. Grote, studying the cotton worm in Georgia, was unable to find any parasites whatever, and from this fact argued that the insect was not a normal member of the Georgia fauna, but flew in every year, probably from the West Indies.

REMEDIES.

In the Fourth Report of the United States Entomological Commission nearly 200 pages were given to the consideration of remedies and preventive measures. All the false ideas which had gained currency among planters were explained away, an extensive consideration of remedies against the insect in all stages was given, and the subject of machinery for the distribution of wet and dry poisons was most elaborately treated. The chapters on remedies in this report have resulted in great benefit to the agricultural community as a whole. The system of eddy-chamber or cyclone nozzles was here first

treated, and modifications of these nozzles are now in active use in all parts of the world for the application of insecticides and fungicides to very many crops. Several elaborate machines for the distribution of wet poisons were invented in the course of the investigation, and all devices which had been patented received

consideration. Although, as just stated, this work has been of great value to agriculture and horticulture at large, its results from the standpoint of the cotton grower have, for the reasons stated in our introduction, amounted practically to nothing down to the present time.

In 1883 Dr. W. S. Barnard, who had been in charge of the insecticide machinery portion of the cotton-worm investigation, was sent to Alabama to make field tests of the largest and apparently most practical machines which had been devised. He found that the large machines, so arranged as to underspray sixteen rows of cotton at once, were comparatively impractical, except in a very few cases. Were cotton so planted that the rows were equally spaced, the machine would work very well, but the inflexibility of the larger machines prevented them from conforming to inequalities of the ground and to uneven rows. Every cotton planter knows that in an average cotton field the necessities of

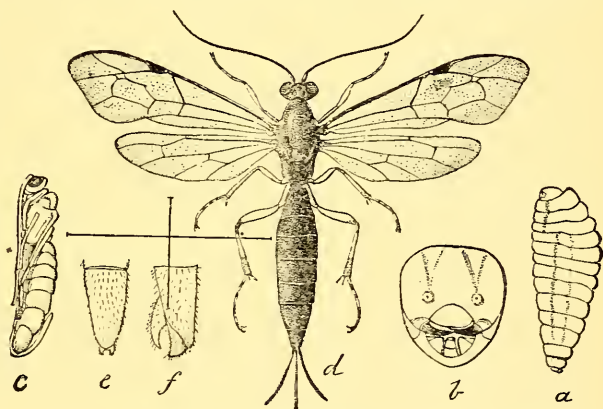


FIG. 16.—*Pimpla conquisitor*, one of the principal parasites of the cotton caterpillar: *a*, larva, enlarged; *b*, head of same, still more enlarged; *c*, pupa; *d*, adult female, enlarged; *e*, *f*, end of abdomen of adult male, still more enlarged (from Fourth Report U. S. Entomological Commission).

the case will not allow of ideally true rows. The rows must run wider or narrower according to the quality of the soil and the size of the plant a certain soil will produce. It was found, therefore, that an attempt to underspray more than four rows at once was practically useless. A good account of the best apparatus for spraying this amount of cotton at a single operation has been published by the Division of Entomology of this Department.¹

We have briefly indicated in the introduction to this article the fact that such extensive remedial work against this insect as was planned in the Fourth Report of the United States Entomological Commission has not of late been found necessary in the South, and have hinted at some of the reasons. Perhaps the main reason, however, is that a change has taken place in Southern agriculture, which has frequently been urged by writers upon economic entomology as most conducive to the limitation of widespread damage by any given species of injurious insect. This is the greater diversification of crops. Cotton is no longer planted everywhere, as in the broad fields which were so common twenty years and more ago. As a characteristic instance, we may take the case of a prominent planter at Columbus, Tex., who in 1880 had 500 acres of cotton under cultivation in a bend of the Colorado River. In 1894 he had of the same area 300 acres in corn, 100 acres in Johnson grass, and only 100 acres in cotton. It is readily seen that such a breaking up of the immense cotton fields of the South will to a great extent prevent any undue multiplication of the caterpillars and consequent migration northward of the moths. Twenty years ago, moreover, remedial work on a large scale was not attempted by cotton planters. Later the knowledge of the importance of poisoning for the early broods has inspired planters with a feeling of confidence, which has since steadily grown, both as the result of successful remedial work on a more or less small scale and the undoubtedly smaller numbers of the worms. Further, the development of the cotton-seed oil industry has been an important factor. In earlier times rank-growing varieties of cotton, producing few seeds, but of long fiber, were grown. Now that cotton seed is worth from \$9 to \$15 a ton, smaller varieties of cotton, with a shorter fiber and a higher proportion of seeds, are more popular. The fields are thus more open, and not only afford a better opportunity for remedial work when necessary, but also show plainly the first "ragging" of the leaves and prevent the worms from working in numbers comparatively out of sight until one or more generations have developed and the moths have become sufficiently numerous to lay eggs for the old and greatly feared "third brood." These points and others have already been reported by Mr. E. A. Schwarz, of this office.² His article is a result of observations made upon an official trip through the cotton belt in the summer of 1894. At many points he found the sentiment among planters to be

¹ Bul. 3, pp. 39-47.

² Insect Life, Vol. VII, No. 4.

that the cotton-worm question is solved. As a result of these observations and of the reports of Professor Atkinson in Alabama and Professor Tracy in Mississippi, as well as from conversations had with a number of influential cotton planters and correspondence with others, we are quite inclined to believe that the simple method of using undiluted and dry paris-green powder which has sprung up throughout the South is probably capable of maintaining present conditions. So far as we know, the large machines recommended in the Fourth Report of the Entomological Commission have never been built and operated by planters. Some effort has been made since the close of the cotton-worm investigation to put patented machines upon the market, and this effort was largely due to the increase of the caterpillars in 1890.¹

The distribution of dry paris green from two bags held at the ends of a pole over the back of a horse or mule is a process which has developed apparently spontaneously. At least ten years ago the process was described to the author in a conversation with Hon. Charles E. Hooker, Member of Congress from the Seventh district of Mississippi. Writing in July, 1890, Prof. G. F. Atkinson, of Alabama, spoke of it as a "recent" method. The Mississippi Experiment Station, in June, 1890, described the method as one which had been recently developed.² Prof. J. S. Newman, of Auburn, Ala., used the process as early as 1887. It is quite probable, however, that this method dates back to early in the seventies. The method is described² by the Mississippi Experiment Station as follows:

Make two sacks of heavy cloth, each about 10 inches long and 4 in diameter, open the whole length of one side and firmly sewed at the ends. We have found 8 ounce osnaburg the best cloth for the purpose. Take a strip of oak or other strong wood about $1\frac{1}{2}$ by 2 inches and 5 feet long, and bore a 1-inch hole 5 inches from each end. Tack one of the sacks to each end of the pole, fastening one of the edges of the opening to each of the narrow sides of the pole.

The sacks can be filled by pouring the poison through a funnel inserted in the holes through the pole, and distributed by riding on horseback through the cotton rows, dusting two rows at a time. A little practice will enable one to do this work very evenly, and care must be taken not to allow the sacks to touch the leaves when wet or the poison will not pass through. When the sacks are freshly filled a very slight jarring will shake out a sufficient amount of the poison, but when nearly empty the pole should be frequently and sharply struck with a short stick, or spaces in the rows will be missed.

¹Three machines were patented in 1890—the Roach cotton-worm destroyer, patented by the James P. Roach Manufacturing Company, Vicksburg, Miss.; the Rogers dry-poison distributor, patented by the Rogers Company, of Lagrange, Tex., and the Brown machine, manufactured and sold by L. M. Rumsey & Co., at St. Louis, Mo. All of these cost \$50 or more each, and while all were probably capable of doing the work claimed for them the sales were small. One company has gone out of business, and the machines of the others have not been extensively used. Should a season of great caterpillar abundance come, either of these machines may be used to good advantage, or the smaller spray distributor described in the Fourth Report of the Entomological Commission, or a number of the spraying machines put upon the market of late years in the North may be adapted to field use in the South.

²Mississippi Sta. Bul. 2.

When used in this way we have found it the best plan to use the poison without any admixture of flour, and if flour is to be added lighter cloth should be used in making the sacks.

With a pole and sacks as described, one man and mule can poison from 15 to 20 acres per day.

THE COTTON BOLLWORM.

(*Heliothis armiger* Hübn.)

Unlike the cotton worm, this insect is by no means confined to America, nor is it confined to cotton as a food plant. It is known in many other parts of the world, and it can not be surmised at the present time whether it has been carried from some one point or whether it is indigenous over its extremely wide range. Its food plants vary in extraordinary degree. In this country it is one of the principal enemies of cotton, of corn, and of the tomato.

The cotton bollworm, the corn earworm, and the tomato fruit worm are all the same species. In addition to these crops, it feeds upon peas and beans, tobacco, pumpkin, squash, okra, and a number of garden flowering plants, such as cultivated geranium, gladiolus, mignonette, as well as a number of wild plants.

GENERAL APPEARANCE, HABITS, AND LIFE HISTORY.

The egg.—The egg is a little larger than that of the cotton worm and more nearly round. It is nearly white in color and rather inclined to yellowish. Examined with a lens, its structure seems to be almost identical with that of the cotton worm. The eggs are laid upon all parts of the cotton plant, occurring most abundantly on the underside of the leaf. A few can be found upon the stalks, many upon the upper surface of the leaves, some upon the involucre, and occasionally they are seen upon the stems of the boll or upon the leaf of the petiole. The eggs are laid just at twilight, and they hatch in from two days to a week.

The larva.—When first hatched, the bollworm looks much like the cotton worm. It is rather darker in color, but also walks like a looper, or measuring worm. It feeds at first near the eggshell, and then begins to wander away, crawling from one leaf to another, until a young bud or boll is found, into which it bores. Frequently several days pass in this search for a boll, and rarely the worm may reach full growth upon a diet of leaves. It is during this early, wandering, leaf-feeding existence that the insect may be destroyed by arsenical poisons, as is true of the cotton worm. When the young worm enters the flower bud the involucre flares open and the young bud or young boll finally drops. This "shedding" of cotton is, however, not caused by the bollworm alone. Other insects are concerned in the damage, and the flaring and dropping occasionally occurs when no insect injury can be found. A very considerable amount of damage may be done in this way, as a single young larva will travel from bud to bud, deserting each before it falls. The bud pierced just before opening is forced into premature bloom, but the worm usually feeds upon the stamens and pistil, rendering it



DESCRIPTION OF PLATE IV.

TRANSFORMATIONS OF COTTON BOLLWORM.

(*Heliothis armiger* Hübn.)

Fig. 1. Egg on underside of cotton leaf.

Fig. 2. Larva one-third grown boring into square.

Fig. 3. Entrance hole of young larva in square, with excremental pellets at edge of hole.

Fig. 4. Nearly full-grown larva just issued from boll.

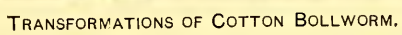
Fig. 5. Full-grown larva on leaf stem.

Fig. 6. Pupa shown in center of underground earthen cell; cell shown in longitudinal section.

Fig. 7. Adult moth, light variety.

Fig. 8. Adult moth with dark forewings.

Fig. 9. Adult moth in resting position, wings slightly elevated, hind border of hind wings slightly showing.



incapable of fructifying. As the bollworms grow they begin to vary greatly in general appearance. Full-grown worms may be found of almost every intermediate stage of color between light green and dark brown or rose. They may be unstriped and unspotted, or they may possess dark stripes or black spots. These color varieties are not caused by different food, since many variations occur in specimens feeding upon the same plant. Upon cotton the larger worms take the larger bolls, the young ones having confined themselves in the main to the flower buds and the newly formed bolls. They then practically progress downward, the young ones being found mainly upon the top crop, while the older ones bore into the older bolls of the middle crop, the bottom crop being seldom seriously damaged by this insect. Often a single worm will practically destroy several large bolls, and one instance is on record where 18 young bolls and many blooms and unopened flower buds have been destroyed by one not fully grown worm. The bollworm is not only a voracious plant feeder, but it is also a cannibal. Older worms feed upon younger ones, and it has often been known to eat the chrysalids of the cotton caterpillar. With an abundance of vegetable food at hand, the larger worms will seize upon their small brothers, biting through the skin and feeding upon the juices of the body. In ears of corn the remains of several young worms are often found, while the strong, large worm which has destroyed them is the only living occupant of the ear. The larva occupies from two weeks to a month in reaching full growth.

The pupa, or chrysalis.—Unlike the cotton caterpillar, the bollworm enters the ground in order to transform. It forms an oval cell composed of particles of earth held together by a loose, gummy silk, or the pupa may be perfectly naked. It is of a light mahogany color, darker toward the head, and the duration of this state is from one to four weeks.

The adult insect.—The adult insect of the bollworm is a moth about the size of the cotton-worm moth, but has a stouter body and is more extensively marked, as well as more variable in its markings. Its general color varies from a dull ochre-yellow to a dull olive-green. The fore wings have a rather dark band near the tip and the hind wings are also bordered with a darker band. The wing veins are lined with black and the fore wings have also several dark spots. There is great variation in these markings, and they are intensified in some individuals and almost lacking in others. When the moth is at rest, the fore wings are slightly open, whereas in the cotton-worm moth they are closed in a roof-shaped manner. The moth flies normally about dusk, lays about 500 eggs, and is not a fruit feeder like the cotton-worm moth. During the day they hide in cowpeas and in clover, when these grow near the cotton field, and fly low with a quick darting motion when disturbed. About sunset they begin to feed upon the honey secreted by the cowpea and blossoms of clover, as well as upon the nectar of the cotton

plant and other honey-secreting plants. Mr. Mally speaks of seeing the moths eating at 3 o'clock in the afternoon, and Mr. Mullen states that he has noticed them feeding freely during all hours except the early morning hours, and during 1892 noted them particularly depositing their eggs in broad daylight.

Number of generations.—The average time occupied by the insect in its transformations from egg to the adult is about thirty-eight days. The number of annual generations is about five. In the cotton-growing States the worms of the first three generations feed usually in the corn fields. In fact, in choice of food plants, cotton seems to be secondary to corn. They feed upon corn by preference until this becomes too hard to be readily eaten. The worms of the first generation make their appearance the latter part of April or early in May, and feed almost exclusively upon the leaves and terminal buds of corn. The second generation, appearing in early June, feed upon the tassels and forming ears of corn, while the third appears in July and feeds upon the hardening corn. When the fourth generation appears, the corn has become too hard for appropriate food and the moths, therefore, fly to neighboring cotton, which carries at that time plenty of tender young bolls. A few worms will have been found upon cotton before this time and will have fed upon the leaves and flower buds only in the absence of bolls. Others will have been found upon tomatoes, if these are grown upon the plantation, while still others have been feeding upon cowpeas. As a general thing bollworms are seen in force upon cotton about the first of August, and usually these individuals belong to the fourth generation. The fifth generation makes its appearance about the middle of September, and about the middle of October, or even earlier, the caterpillars enter the ground for transformation to pupæ.

Hibernation.—The bulk of the bollworms hibernate in the pupa state underground. In a warm fall the moths have been known to issue during the month of November, and Mr. Mally has shown that frequently a few moths hibernate. These hibernating moths appear and begin laying eggs much earlier than the moths which issue from overwintered pupæ. This results in something of a confusion of generations the following season, and at Shreveport, La., Mr. Mally found a series of small broods along with the more or less regular large ones, a sixth generation of worms appearing a little later in the fall and hibernating in the pupa state. In evidence of this fact he adduces the finding of young bollworms as late as November 20. Young and old worms may, in fact, be found simultaneously after the middle of May. Mr. Mally's observations, however, were founded upon two seasons' observations only, and this state of affairs may be exceptional, particularly as the winter of 1890-91, when he made his observations, was unusually mild in Louisiana and the spring earlier than usual. In Arkansas four and five generations are found in the northern and southern portions of the State, while in southern Texas six generations and a partial seventh seems to be the rule. The determination of the time of the appearance of

the several generations of moths for each differing locality is of very considerable importance, and can only be made by local observers. It is of importance in arranging for the trap-crop method of protecting cotton, which will be discussed under the head of remedies.

NATURAL ENEMIES.

The bollworm has by no means as many natural enemies as the cotton caterpillar. The latter insect feeds exposed upon the leaves, and is, therefore, subject to the attacks of predaceous and parasitic insects as well as birds. The bollworm, however, as a general thing, feeding in the interior of the cotton boll, or ear of corn, or fruit of tomato, or pea or bean pod, is not readily found. In fact, although birds have been noticed to feed upon it, it was long considered to be absolutely free from true parasites. Riley, however, bred a *Tachina* fly from the larva, and Hubbard reared the little egg parasite *Trichogramma pretiosa* from the bollworm eggs in Florida. The more recent investigations of Mally have resulted in finding four additional parasites. One of these is an egg parasite of the genus *Telenomus*. Another is a species of *Limneria*, while the other two are the common *Euplectrus comstockii* How. and *Chalcis ovata* Say, which are such abundant parasites of the cotton worm. The hairy or downy woodpeckers are frequent visitors of cornfields and have been seen to extract the worms from infested ears.

REMEDIES.

Lights for trapping moths.—This is one of the remedies which have been most often advised, and has been very extensively used in parts of the South, particularly in Texas. Schwarz, in 1879, found that a small trap lantern was extensively used by planters in the vicinity of Hearne, Tex., and was inclined to think that some good was accomplished by its use. The same year a large tomato grower at Mandarin, Fla., built large fires in his fields, with the evident result of greatly lessening the number of worms in his crop, which had the previous year been almost entirely destroyed by them. In view of these facts, Mally, during his two summers' investigations, made extensive experiments with trap lights for the moths. He has carefully tabulated all the insects which were captured in this way.¹ A few bollworm moths were caught, but these apparently by accident, and a thoroughly unprejudiced conclusion from his experiments must be that the use of lights for attracting and trapping bollworm moths is without beneficial result. The other insects caught by the light were found to be about evenly divided between those which are beneficial and those considered injurious; but most of the insects called injurious are of no especial economic importance in the cotton region and should be omitted from consideration in forming conclusions. The use of lights, from a cotton-growing standpoint, is really a disadvantage, and money expended in this practice is without doubt entirely lost.

¹ U. S. Dept. Agr., Div. of Ent. Bul. 29.

Poisoned sweets.—Together with the use of lanterns for attracting the moths, poisoned sweets have been recommended for many years. The first experiment of this kind of which we are aware was made by B. A. Sorsby, and is recorded in the Annual Report of this Department for 1855. He used vinegar and molasses in plates set upon small stakes in the cotton field, and his statement was that he captured from 18 to 35 moths to each plate for several days. Mally also experimented in this direction and found that a modification of this remedy is more or less effective. He advises the planting of a few rows of cowpeas as a trap bordering the cotton fields. They should be planted so late as not to reach the height of blooming before the destructive August brood appears. A portion of the row should be sprayed over every night with a mixture of 4 ounces of beer to 2 ounces of potassium cyanid solution. The moths will be attracted by this mixture and will be destroyed by it. The mixture dries readily and hence if applied in the afternoon will not result in the destruction of any day-flying beneficial insects.

Poisoning the worms.—The careful study which has been made of the natural history of the bollworm, particularly that by Dr. William Trelease, in Alabama, in 1880, shows that where arsenical poisons are applied for the so-called third brood of the cotton worm, about August 1, many bollworms are destroyed. It is about this time that many young worms are hatching from the eggs and feeding for a longer or shorter space of time on the leaves before entering the bolls. It was, therefore, thought at the time when Comstock's report on cotton insects was written that the poisoning for the cotton worm, which was so strongly recommended and which was so necessary under the conditions governing at that period, would largely reduce bollworm injury. In fact, as we have shown in our opening paragraph, the bollworm itself at that time was by no means such a factor in cotton growing as it is at the present time. With the great reduction of damage done by the cotton worm and the great increase of that done by the bollworm, however, poisoning for the cotton worm has become comparatively rare, and on account not only of the greater abundance of bollworms, but also of the consequent greater confusion of generations of this insect, and the fact that not more than half at the outside could be destroyed by poisoning at any one given time, this method has largely lost its former value as a bollworm remedy. Still, in seasons of great bollworm abundance, and where early trap-crop methods have been neglected, poisoning, as recommended in an earlier paragraph, under the head of "The cotton caterpillar," will result in saving at least a part of the crop.

Trap crops.—In the intelligent handling of trap crops the cotton planter will find by far the most efficacious preventive of bollworm damage. This suggestion is an old one. It was proposed by Sorsby in 1855, by E. Sanderson in 1858, and by Peyton King in 1859. It was recommended by Comstock after careful preliminary observations by

Trelease in 1879, and Riley in 1885 gives it at least equal rank as a remedy with poisoning. The complete development of the trap-crop system, however, rests upon the studies and recommendations made by Mally;¹ and S. B. Mullen,² of Harrisville, Miss., has written in a most practical manner relative to corn. Mally's recommendations are, in brief, when planting cotton leave vacant strips of 5 rows for every 25 of cotton. In these 5 rows, at the earliest possible time, plant 1 row with an early maturing sweet corn. It should not be drilled in too thickly, as a minimum number of plants and ears is desired. During the silking period frequent careful examinations must be made as to the number of bollworm eggs. As soon as no more fresh white eggs are found each morning, the silk ends of the corn should be cut away and burned or fed to stock in order to destroy the young worms and the eggs. A few eggs may also be found upon the leaves of the plants, and since no more growth is to be made the plants should be cut and destroyed. Then 3 more of the rows should be planted to dent corn at such a time as to bring the silking period about the 1st of July or a little later. Upon these rows very large numbers of eggs will be laid, but they should be allowed to mature in order that the natural enemies which parasitize the eggs and prey upon the larvæ may not be destroyed. The crowded condition of the worms in the ears developed in these 3 rows will induce cannibalism to such an extent that the number of worms reaching maturity will be reduced to the minimum, and these can well be allowed to escape if the natural enemies are saved thereby. To trap these escaping individuals, however, the fifth and last row of the vacant strips should be planted to sweet corn at a time which will allow it to reach full silk about August 1, since the majority of the moths begin issuing again about that time. This last row should be carefully watched, and the corn should be cut and destroyed as soon as it appears that no more eggs are being deposited. Mr. Mally found that the corn produced by the second planting is likely to be large enough in quantity to pay for expense of cultivation and the sacrifice made by cropping the 5 rows in corn instead of cotton. Moreover, he thinks that if the first two plantings are well managed a number of the earlier broods of the bollworm will be so reduced that the August brood will not be capable of inflicting great injury, and therefore in the less-infested regions the third planting may be dispensed with. He further found that it was not necessary to crop the entire plantation with this 5 to 25 rows of corn to cotton. If 5 acres be planted in this way for every 50 acres of cotton, or even 5 acres of trap alternate for 75 or 100 acres, the crop of the entire plantation may be protected. The accompanying diagram (page 340) of a field of 1,050 acres will illustrate the proposed system.

¹For the full details of Mally's experiments, see U. S. Dept. Agr., Div. of Ent. Bul. 29.

²Insect Life, Vol. V, pp. 240-243.

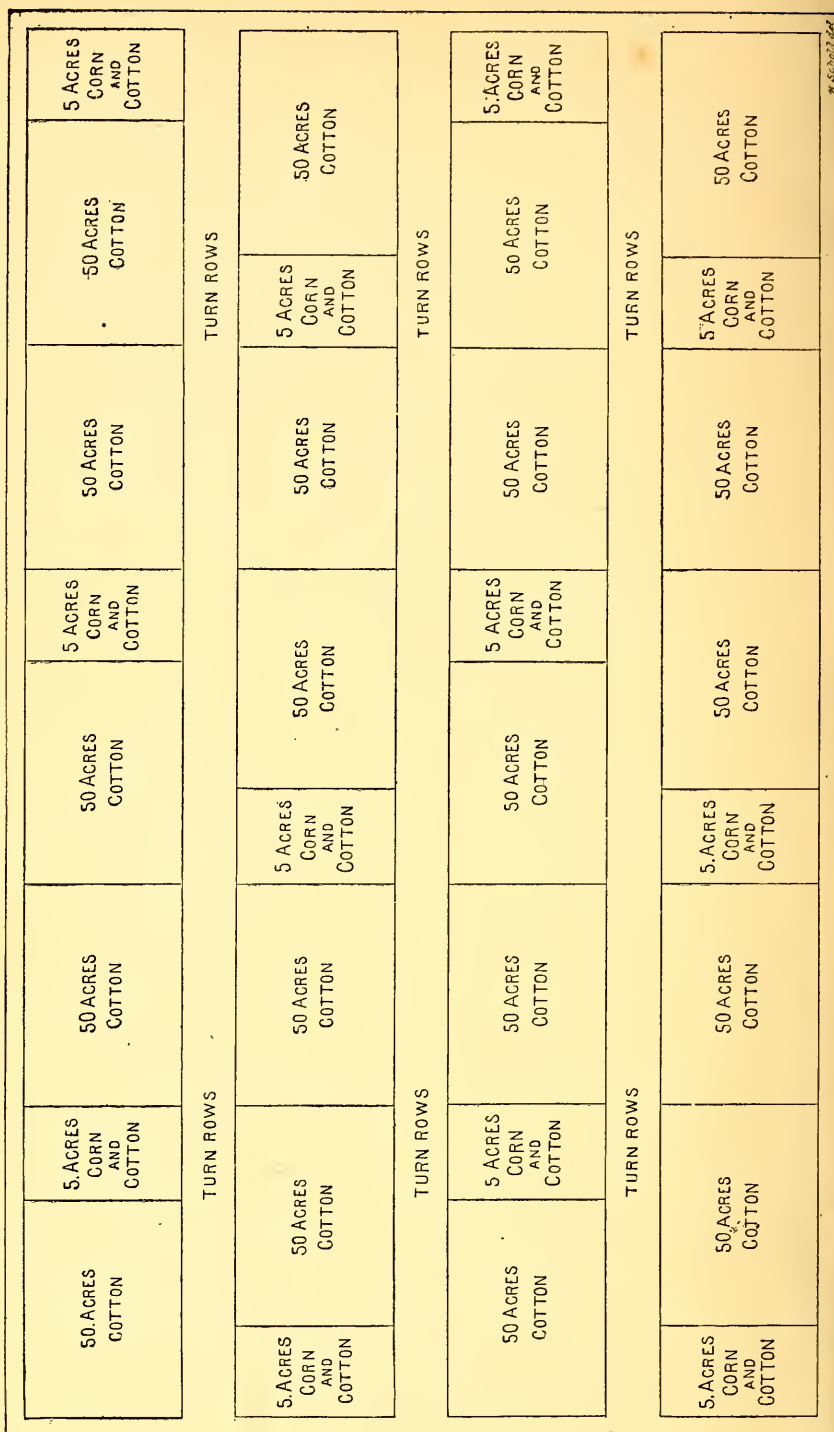


FIG. 17.—Diagram of cotton field, showing location of trap corn.

THE MEXICAN COTTON-BOLL WEEVIL.

From the present outlook the most important of the insects which damage the cotton boll, next to the bollworm itself, is the cotton-boll weevil (*Anthonomus grandis* Boh.).

GENERAL APPEARANCE AND METHOD OF WORK.

This insect is a small, grayish weevil, of the shape and general appearance shown in fig. 18, *a*, and measuring a little less than a quarter of an inch in length. It is found in the cotton fields throughout the season, puncturing and laying its eggs in the squares and bolls. The larvæ, of the shape and appearance shown at fig. 18, *c*, and measuring a little over three-eighths of an inch in length when full grown, live within the buds and bolls and feed upon their interior substance. The squares attacked usually drop, but most of the damaged bolls remain upon the plant and become stunted or dwarfed, except late in the season, when they either dry or rot.

DISTRIBUTION.

The insect through its ravages caused the abandonment of cotton culture around Monclova, Mexico, about 1862.

Two or three years ago cotton was again planted in that vicinity, but the weevil immediately reappeared and destroyed the crop. At Matamoras the weevil was noticed eight or ten years ago. About 1893 it crossed the Rio Grande at Brownsville, Tex., and in 1894 was noticed in the country around San Diego, Alice, and Beeville. At the close of the season of 1894 the insect occupied a territory extending to the north a little beyond Beeville, a few miles to the east of that point, and southwest to the neighborhood of Realitos, on the National Mexican Railway. The greatest damage seems to have been done along the lower Nueces River. During 1895, and particularly in the latter part of the season, it extended its range to a considerable extent. Toward the east it was found in moderate abundance along the valley of the Guadalupe River at Victoria, Thomaston, and Cuero. North of its old range it extended to Kenedy, Floresville, and many points in the country lying between the latter place and Cuero. A single field was found near San Antonio which contained weevils in large numbers, and in the same way a single field

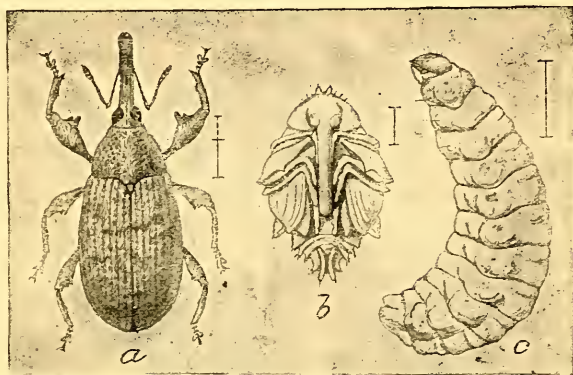


FIG. 18.—The cotton-boll weevil (*Anthonomus grandis*): *a*, adult beetle; *b*, pupa; *c*, larva—enlarged (from Insect Life).

was found far to the east, at Wharton, in which the weevils had appeared late in the season. The exact localities where the insect was found during 1895 are indicated on the accompanying map.

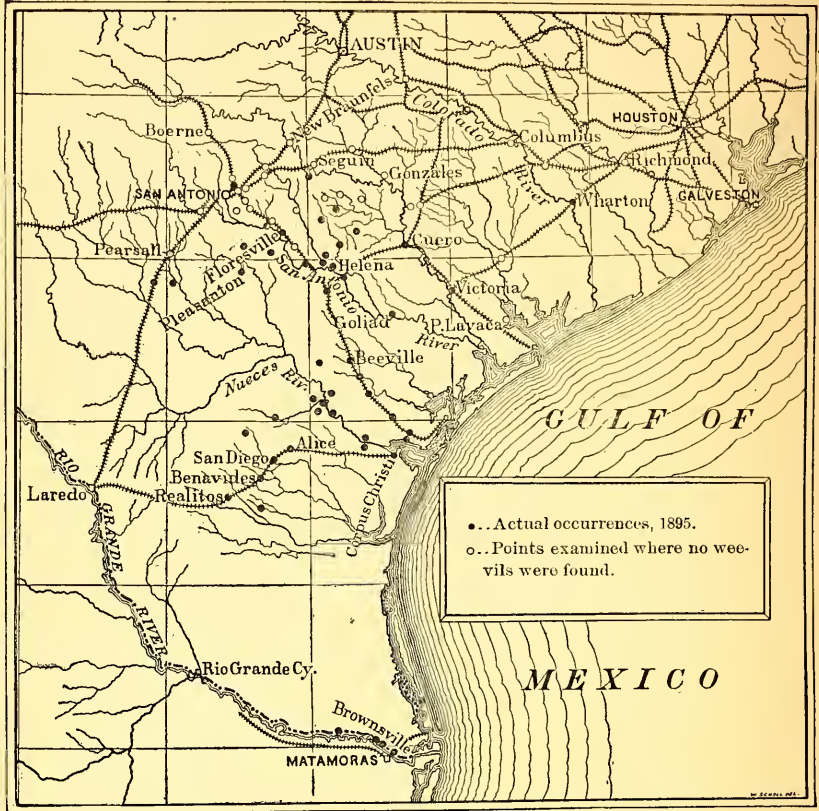


FIG. 19.—Map showing distribution of the Mexican cotton-boll weevil in 1895.

NATURAL HISTORY AND HABITS.

The insect passes the winter in the weevil state. It can be found on the cotton plant until late in December, and, in fact, as long as any portion of the plant is green. It is found most abundantly in the early winter hidden between the involucre and the boll, and later it frequently works its way down into the dry and open bolls. All the specimens found by Mr. Schwarz in such situations in the late spring of 1895 were dead; but Mr. Townsend found a few living in March. The dry boll is probably not a frequently successful hibernating place. Judge S. G. Borden, of Sharpsburg, however, writing under date of January 27, 1896, states that the weevil at that time was being found nearly every day in the dry bolls; but this statement lacks the significance which it might otherwise have had as bearing on the question of hibernation

from the fact that no heavy frost had probably occurred up to that time at Sharpsburg.

With the cutting of the plants, or with the rotting or drying of the bolls as a result of frost, the adult weevils leave the plant and seek shelter under rubbish at the surface of the ground, or among weeds and trash at the margin of the fields. Here they remain until the warm days of spring, when they fly to the first buds on such volunteer plants as may come up in the neighborhood. They feed on these and lay their eggs on the early squares, and one or perhaps two generations are developed in such situations, the number depending upon the character of the season and the date of cotton planting. By the time the planted cotton has grown high enough to produce squares the weevils have become more numerous, and those which have developed from the generation on volunteer cotton attack the planted cotton, and through their punctures, either for feeding or egg laying, cause a wholesale shedding of the young squares. It seems to be an almost invariable rule that a square in which a weevil has laid an egg drops to the ground as a result of the work of the larva; in the square on the ground the larva reaches full growth, transforms to pupa, and issues eventually as a beetle, the time occupied in this round approximating four weeks. Later, as the bolls form, the weevils attack them also and lay their eggs in them, and the larvæ develop in the interior just as with the squares. The bolls, however, do not drop. Figs. 20, *a*, and 20, *b*, show the larvæ in the squares, and fig. 20, *c*, shows a young boll cut open and the pupa in its customary position.

There is a constant succession of generations from early spring until frost, the weevils becoming constantly more numerous and the larvæ and pupæ as well. A single female will occupy herself with egg laying for a considerable number of days, so that there arises by July an inextricable confusion of generations, and the insect may be found in the field in all stages at the same time. The bolls, as we have just stated, do not drop as do the squares, but gradually become discolored, usually on one side only, and by the time the larva becomes full grown generally crack open at the tip. While in a square one usually finds but a single larva, in a full grown boll as many as twelve have been found. In



FIG. 20.—The cotton-boll weevil: *a*, newly hatched larva in young square; *b*, nearly full-grown larva *in situ*; *c*, pupa in young boll picked from ground.

any case, however, the hatching of a single larva in a boll results in the destruction of the boll to such an extent that its fiber is useless. Where no serious frost occurs in December, the insects all, or nearly all, reach maturity and enter hibernating quarters, although larvæ have been found even in January at Sharpsburg. Whenever a heavy frost comes in this month, or before, the observations show that those insects

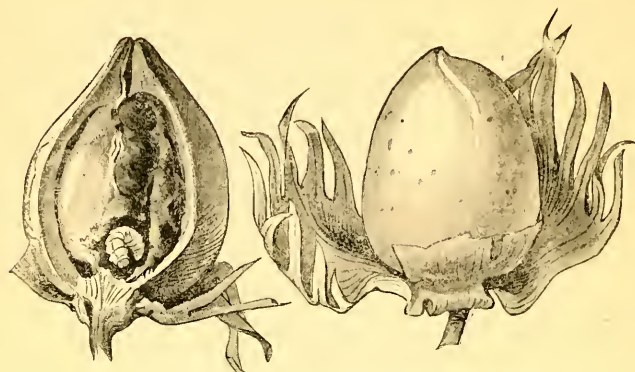


FIG. 21.—Mature boll cut open at left, showing full-grown larva; the one at the right not cut, and showing feeding punctures and oviposition marks.

which have not reached the beetle stage are nearly all killed. From this fact, it follows that the insect will probably not prove as injurious in other portions of the cotton belt as it is in southern Texas.

It was found during the latter part of 1895 that the weevil was present in a number of localities in which it was not known by the planters themselves to occur. It is important that every planter who lives in or near the region which we have mapped out should be able to discover the weevil as soon as it makes its appearance in his fields. Where a field is at all badly infested, the absence of bloom is an indication of the presence of the insect. In the early part of the season the weevils attack the squares first, and these wilt and drop off. A field may be in full blossom, and as soon as the insect spreads well through it hardly a blossom will be seen. This dropping alone, however, is not a sufficient indication of the weevil's presence. Squares are shed from other causes, but if a sufficient number of fallen squares are cut open the cause will be apparent. The characteristic larva of the weevil will be quite readily recognizable on comparison with the figures which we publish herewith.



FIG. 22.—Late-fall boll, showing how beetles hide between boll and involucre.

As stated above, the bolls do not drop. The punctures made by the weevils in feeding, however, are comparatively characteristic, and where a boll is discolored and has begun to crack at the tip the larva or the pupa can be seen without trouble on cutting it open. Late in the season the weevils themselves will be found between the involucre and the boll, as shown in fig. 22; or in their absence the

feeding marks and the yellow, granular excrement which collects in the involucre at the base of the boll are excellent indications.

POPULAR NAMES.

In south Texas, among Spanish-speaking people, the insect is generally known as the "picudo," a descriptive name which refers to the snout or beak of the insect. English-speaking planters generally referred to the insect at first as "the sharpshooter," a term which for many years has been applied to any insect which causes through its punctures the shedding of the squares or the rotting of the bolls. As there are several native insects that are commonly called sharpshooters and which, though injurious, are by no means to be compared with this insect, it becomes necessary to discourage in every way the use of the word sharpshooter as applied to this weevil. The adoption of the term "Mexican cotton-boll weevil" for the new pest is recommended. The term sharpshooter is now much less generally applied to the weevil than it was at first. Planters generally now refer to it as the boll weevil, or the Mexican weevil, or the Mexican boll weevil.

PARASITES AND NATURAL ENEMIES.

It is safe to say that little assistance will be derived from the work of natural enemies and parasites upon this insect. Of the former none of any importance have been found. Several parasites, however, have been found to attack it, and in one or two localities some little good has resulted from their work. They have only been abundant, however, late in the season, after the weevil has completed its damage for the year, and at a time when a minimum of good can be accomplished by the destruction of the larva. The majority of the weevils in a given field fail to hibernate successfully, being killed by cold weather or some other cause, so that the work of parasites at this time does not count. Careful estimates, however, show that from 15 to 20 per cent of the weevil larvæ in fallen squares in November at Beeville and Kenedy were destroyed by parasites. There is a bare possibility that in the original home of the weevil (south Mexico and some Central American States, as well as certain of the West Indies) more efficacious parasites could be found, but this possibility is hardly sufficiently strong to warrant the expense of a search expedition.

REMEDIES.

In considering the matter of remedies we must start with the statement that experience has shown that none of the general applications of insecticides will be of the slightest value against this species. There are measures, however, which cotton planters may adopt, and which, if carried out generally at the right time, will postpone the appearance of the insect in injurious numbers for one or two generations, even if they will not prevent an undue multiplication of the species. These

measures are directed against the overwintered weevils and the larvæ of the first generation, since where the insect has once become numerous nothing can be done to save the crop from practical destruction.

We have noticed that the weevils first appear in spring among clusters of young squares on the most advanced cotton plants. This suggests the possibility of trapping these earliest beetles by means of a very few cotton plants especially grown for this purpose. These plants must be grown at convenient points, must be protected from frost, and forced by watering, so that they will branch out and acquire buds even in advance of the volunteer cotton. The weevils, which issue from hibernating quarters on the first warm days, will be attracted to these plants at once, and can be easily collected and killed, if the plants are examined daily until the cotton in the fields has become of some size. It is not likely that this plan will appeal to the average cotton planter, but we are convinced that much good can be done by its general adoption.

The fact that the spring generation develops only upon volunteer cotton has suggested the possibility that the insect will not spread beyond the region where volunteer cotton will grow in spring, but unfortunately this possibility is by no means absolutely to be relied upon. Nevertheless, the destruction of such volunteer plants as come up in cornfields and in abandoned fields which the previous year were planted to cotton can not be too strongly recommended, for it is a matter of observation that the shade afforded by the corn or the rank-growing weeds which come up in abandoned fields is especially favorable to the development of the weevils.

While the plants are young, and where labor is as cheap as it is in south Texas, a great deal of good can be accomplished by picking and burning the fallen squares, and if this is done promptly a large number of the insects will be destroyed. It should be done at least twice, at intervals of three weeks, during the period while the plants are small. As soon as the plants begin to branch out, however, this method becomes impracticable, on account of the difficulty of finding the squares on the ground.

The idea of picking the affected bolls during the cotton picking was suggested in the writer's first published account of this insect. It was thought that the affected bolls could be so readily recognized that many thousands of the insects could be destroyed by the cotton pickers by picking these affected bolls and carrying them away in a separate receptacle to be burned. The amount of extra labor involved in this operation, however, would be very considerable, and the affected bolls in many instances are not to be recognized at a glance.

These measures, aside from the last one, together with early planting and clean cultivation, comprise all that can be done to save the crop of the season in which remedial work is begun. Where, however, these simple measures have been neglected, or where, in spite of their adoption,

the weevils are injuriously abundant in the early fall, a more or less efficient method of reducing the numbers of the insects and preventing such great damage the ensuing year is at hand. In general, a good first crop may be gathered in spite of the weevils. The numbers of the insects in the affected region are small during the early part of the year. Our three years' experience shows that they become destructively abundant in the month of September and that it is after this date that a general spread takes place. Under favorable conditions and in the localities most badly affected the top crop is sure to be destroyed. This prospective loss will become evident in September from the absence of bloom. The prospect of any further picking of cotton being thus rendered so extremely small, a suggestion is obtained as to what is perhaps, after all, the most practical way of reducing the numbers of the weevils and securing approximate immunity for the succeeding summer, and that is the cutting down and burning of the plants at a time when it becomes evident that the cotton yet to be gathered will be very small in quantity. In many localities this could be done to very great advantage as early as the beginning of October, and several large growers of cotton have undertaken this means. The success of this measure will naturally depend upon uniformity of action among the planters of a given region, and the difficulty of securing this uniformity is the main argument to be used against it. Only about half the cotton in Duval County, for example, seems to be grown by the proprietors of the land; the remainder is grown by renters, who will be not at all disposed to cut down their plants so long as a chance remains of picking a handful of cotton. In this way the plants in many fields will doubtless be left standing until toward the end of December.

Could anything like uniformity be secured, either by legislation or otherwise, it is in this fall destruction of the cotton that our best hope lies at the present outlook; and in this connection the further suggestion should be made that not all the plants in any given field should be destroyed in this way. All the insects which are in the larval and pupal condition will be destroyed when the cotton is burned, but those which may be in the beetle stage will, by flight, escape alive. If, therefore, a certain number of the plants are left standing in every field, these plants will attract the remaining beetles, which will settle upon them, so that they may readily be collected day after day and destroyed. If the plants are all cut down and burned, the beetles will spread far and wide; but if a few are left standing in this way, the weevils will concentrate upon them in such a way that they can be easily handled. Where there is obviously a certain amount of cotton still to be gathered after the early part of October, it may be an object to postpone this cutting down and burning of the plants. We have found that the weevil continues to breed and may be found in the bolls in all stages up to the time of the first frost. The cutting and burning will then accomplish a considerable amount of good, even if done during November, although October would be far better.

From the present outlook, therefore, the best hope which the cotton planters in the affected region will have for the future will be in following this last-described method every autumn, and the more thoroughly and uniformly (and, in fact, the earlier) this is done in any given locality the greater will be the chance for a good crop the following year. Unfortunately, after talking with many cotton planters in this region, we are by no means sure that the plan will be at all generally followed, for the reasons suggested above; and as the prospects of these planters themselves, as well as the owners of cotton plantations in adjoining regions as yet uninfested, will depend almost entirely on the general adoption of this plan or some better one which may yet be discovered, it becomes necessary to look forward to the enforcement of remedial work by legislation.

It will be greatly to the interest of all growers of cotton in the prolific district lying to the northeast of the region at present infested to urge the passage of an act by the legislature which will bring about the enforcement of remedial work. This act should provide for the appointment of commissioners in each county upon the application of a certain number of the citizens of that county. These commissioners should be empowered to enforce remedial work, to levy penalties, or to have the work done by their own agents, the cost to be assessed upon the property. It will be well to let this law have a wide bearing, and not to confine its application to this particular insect, but cover all injurious insects, in case of future emergencies of a similar nature. Such a law should be passed in every State in the Union. Though it might remain inoperative for years, its application would be available in case of any sudden emergency, such as the introduction from a foreign country of a new injurious insect or the sudden multiplication and spread of any one of our native species.

SUMMARY OF REMEDIES.

(1) Trapping overwintered beetles by means of a few early planted cotton plants.

(2) Destruction of volunteer plants in cornfields or abandoned fields.

(3) Picking fallen squares as fast as practicable, from the time the squares are formed on the plant.

(4) Cutting and burning the cotton stalks as early in the fall as practicable, and, if possible, plowing the cotton fields at the same time.

(5) Trapping the last weevils in the field by means of a few plants left standing.

There can be no doubt that this insect may become the most serious enemy to the cotton plant with which cotton growers in this country have had to contend, and every effort should be made to prevent its further spread. The writer believes that this can be accomplished, if, by concerted action of the planters, the recommendations just made are carried out throughout the infested region.

OTHER COTTON INSECTS.

The reports of the Entomological Commission and the report by Comstock, published by this Department in 1879, treated only incidentally of the other insects which affect the cotton plant. The main endeavor in the large investigation was to cover the ground of the cotton worm; even the bollworm was considered as of minor importance. In fact, the only consideration given to the subject of the other insect enemies of this crop has been the description of a few species by Glover in several of the earlier reports of this Department, and in his copper-engraved folio entitled "Cotton insects." The writer has compiled a list of the insects found in cotton fields and which are mentioned in the reports of Glover, in the bulletins and special reports of the Division of Entomology, in Bulletin 3 and the Fourth Report of the Entomological Commission, together with those mentioned in the notebooks of the Division of Entomology and of the United States Entomological Commission, and has added to this list the species mentioned in the monthly reports of the statistical division of this Department, those collected by Ashmead in Mississippi in the summer of 1893,¹ those collected by Barnard in Louisiana in 1879-80, and those collected by Mally in Mississippi and Louisiana in 1890-91, together with a few collected by Banks in Louisiana in 1891.

The list as a whole comprises about 465 species. A small proportion of these, however, can be considered as injurious to the cotton plant, and still smaller numbers have attracted the attention of cotton planters through their injuries to the crop. Many of them are parasitic or predaceous upon species which damage the plant to a greater or less extent, while many others are accidental visitors to the cotton fields, and might have been collected as readily in fields of corn or cowpeas in the same general locality. Some little consideration, however, may be given here to certain species which occasionally accomplish considerable damage.

CUTWORMS.

The first insect which attacks the young cotton plant in the spring is liable to be a cutworm. Soon after the young plants come up, and often after they are fairly well grown, they are liable to be cut off at the surface of the ground by one of these caterpillars, all of which have the habit of hiding beneath the surface of the ground by day and coming out to work at night. The work of these insects in general was frequently mentioned by Glover, but the species were not determined. In Riley's report as Entomologist to this Department for 1884, the subject of cutworms in cabbage fields received careful treatment, and the statement was incidentally made upon page 291 that the granulated cutworm

¹Certain of these have been mentioned by Ashmead in his articles in *Insect Life*, Vol. VII.

(the larva of *Feltia annexa* Treitschke) is probably the most common of the species collectively designated by Glover as the "cotton cutworm." This species is illustrated herewith. A number of other species, however, are undoubtedly concerned in this damage. The larvæ of *Feltia malefida*, *Noctua c-nigrum*, *Agrotis ypsilon*, and *Plusia rogationis* have been found to have similar habits.

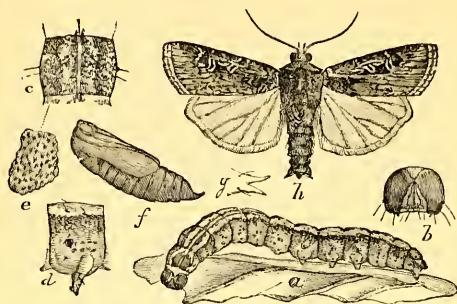


FIG. 23.—*Feltia annexa*: a, larva; f, pupa; h, moth—natural size (after Riley).

Since the discovery of the poisoned-trap system, there is no reason why land should be allowed to be infested by cutworms year after year. Dr. A. Oemler, of Wilmington Island, Georgia, the author of the excellent little book entitled "Truck farming in the South," had been for some years in the habit of scattering bunches of grass through his fields, or placing here and there turnip or cabbage leaves, and collecting from time to time the cutworms which had gathered under them. At the suggestion of Professor Riley, in 1882 or 1883, he began poisoning these vegetable traps with paris green, which saved the trouble of examining them and killing the worms by hand. The method proved perfectly satisfactory, and has since been extensively used in all parts of the country. An innovation was later adopted by Prof. A. J. Cook, of Michigan, who poisoned a patch of grass with a broadcast sprayer, afterwards cutting the grass, loading it on a wagon, and pitching it with a fork in little bunches here and there through the field. Any early vegetation may be used in this way, and extensive fields can be economically rid of the worms before most crops show themselves above ground.

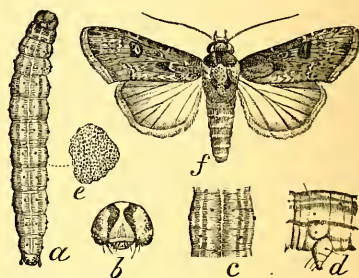


FIG. 24.—*Feltia malefida*: a, larva; f, moth—natural size (after Riley).

PLANT LICE.

While the cotton plant is yet young and tender, the damage which plant lice do by gathering upon the young shoots and tender leaves and curling and distorting them may be very considerable. The species engaged in this work is generally, if not always, *Aphis gossypii* Glover. Recent investigations by Mr. Pergande, of this division, have shown that this insect is identical with the species which occurs commonly through the South, and the North, too, for that matter, upon melons

and cucumbers, and which was described by Ashmead as *Aphis citrulli*, and by Prof. S. A. Forbes as *Aphis cucumeris*. It has very many food plants, as has been shown by Pergande, and remedial work, except upon the crop which it is proposed to protect, is practically out of the question. In other words, there is no single alternate perennial food plant, as in the case of the hop aphid, upon which the insect may be destroyed during the earlier or later portion of the year. As the cotton plant grows larger and stronger, the work of the cotton aphid becomes of no importance, partly through the hardier condition of the plant, but also through the fact that the many natural enemies of the lice increase to such numbers as nearly to annihilate them. There will seldom be, therefore, any necessity for the application of remedies; and, indeed, as nothing can be done except to spray with a dilute kerosene-soap emulsion or a resin wash, it is a question whether it will not pay the cotton grower much better to replant the damaged spots.

LEAF-FEEDING CATERPILLARS.

There are many Lepidopterous larvæ which feed upon the leaves of the cotton plant; few of them, however, are confined to the cotton plant for food. One of the species most commonly noticed, *Cacaecia rosaceana*, is known from its work as the leaf roller—a title under which another species, *Dichelia sulphureana*, may also be included. Both species are general feeders and are found in various parts of the country, the former upon apple, rose, peach, cherry, birch, clover, honeysuckle, beans, strawberries, and other plants, and the latter upon clover and grass. The larvæ of the former, in addition to folding the leaves of cotton and feeding within the roll, sometimes bore into the young bolls (Mally), but this method of damage is rare.

Several of the larger Bombycids also feed in the larval state upon cotton. Among these we may mention the large royal horned caterpillar, *Citheronia regalis*, sometimes known as the "Hickory Horned Devil," a very large, green caterpillar with long recurved red horns; the large green, somewhat hairy larva of the imperial moth (*Eacles imperialis*); and the large spiny larva of *Ecpantheria scribonia*, as well as the yellow-green stinging caterpillar of the Io moth, *Hyperchiria io*, and the "woolly bear" caterpillars of *Leucartia acraea*, *Spilosoma virginica*, and *Arctia phyllira*. The last-named species seems to possess greater capabilities for damage than any of the others, and H. E. Weed has reported a case in which several acres were entirely defoliated by it about the middle of June, in Mississippi.¹

Two bagworms are also occasionally found feeding upon cotton leaves, constructing their cases from fragments of the leaves sewed together with silk. These are the common bagworm of the North, *Thyridopteryx ephemeraformis*, and Abbot's bagworm, a southern species (*Oiketicus abbotii*).

¹ Insect Life, Vol. V, p. 111.

Late in the fall the common grass worm, or fall army worm (larva of *Laphygma frugiperda*), ranges through the cotton fields, feeding upon volunteer grass, and occasionally ragging the leaves of the cotton plant. Two allied native species, viz, *Prodenia commelinæ* and *P. flavi-media*, also occasionally feed upon cotton leaves.

The larva of the handsome little butterfly known as *Thecla pæas* feeds upon the leaves and occasionally bores into the bolls.

The larvæ of *Acronycta oblongata* and *Anisota senatoria* have also been found by Mally engaged in this work.

In a limited section of the country, namely, in portions of Texas and the Indian Territory, the so-called garden webworm, *Pyrausta nantalis*, occasionally does some damage to the cotton crop, as it did in 1885. Feeding principally upon corn, its injury to cotton is incidental, yet it may, in the early part of the season particularly, do some little damage to this crop. Its preference for corn is noticed mainly when fields overrun with pigweed and careless weed (*Amarantus* spp.) are broken up for planting, and, in fact, these weeds seem to be its natural food. It

will probably never do serious damage to cultivated crops, except where these weeds have been allowed to run wild for a season or so and are then plowed under and the land planted to some useful crop. The small green caterpillars feed upon the leaves, concealing themselves between them during the day and skeletonizing them at night.

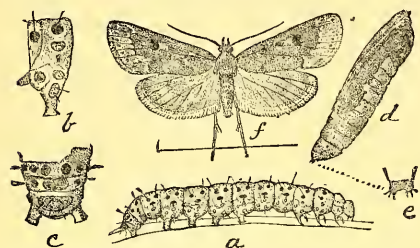


FIG. 25.—*Pyrausta nantalis*: a, larva, enlarged; b, side view of abdominal segment of same; c, dorsal view of anal segment, still more enlarged; d, pupa; f, moth, enlarged (after Riley).

The remedy for any or all of these leaf-feeding caterpillars, whenever one of them occasionally becomes so abundant as to threaten damage, as happened with the *Arctia phyllira* above mentioned, will be to spray with paris green, or dust it on dry, as for the cotton caterpillar.

OTHER INSECTS WHICH DAMAGE THE LEAVES.

Among the other insects which injure the foliage of the cotton plant, grasshoppers are the most prominent. Several species have this habit, and the list of cotton insects contains the names of fourteen which are found upon the plant. Here also the damage to cotton seems incidental; they feed by preference upon grass. The species which ordinarily cause the greatest alarm among cotton planters are the large American locust (*Schistocerca americana*) and the lubber grasshopper (*Brachystola magna*). The paris green treatment will again be effective here, but when grasshoppers occur in considerable numbers, attracting them to patches of a mash made of sweetened bran and arsenic will prevent leaf feeding to a great extent.

Many leaf hoppers and several leaf-feeding beetles have been found

upon the cotton plant, but need not be particularly mentioned here. In many portions of Texas the leaves are frequently cut off by the so-called leaf-cutting ant, *Ecodoma ferrens*. One of the few practical remedies against this destructive insect, which damages fruit trees and other field crops as well as cotton, consists in tracing the ants to their nest (which is often an extremely difficult thing to do) and destroying them there by copious applications of kerosene or bisulphid of carbon. Another method, which has been practiced with some success by an intelligent Texan, is to spread a line of cyanid of potassium across the well-defined path by which the ants leave their nest. This kills very many, and deters the ants from taking the direction of the particular path thus obstructed.

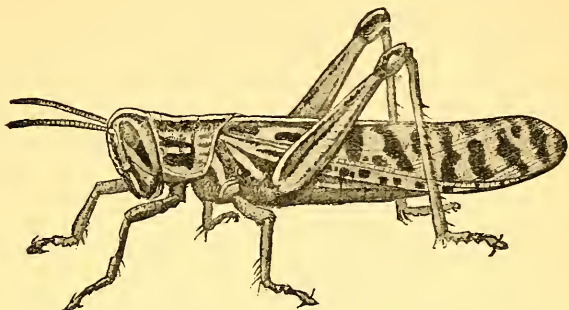


FIG. 26.—*Schistocerca americana*: adult female—natural size (from Insect Life).

INSECTS DAMAGING THE STALK.

Puncturing of the terminal portion of the stalk by plant bugs occasionally occurs, but is comparatively rare. There is but one borer in

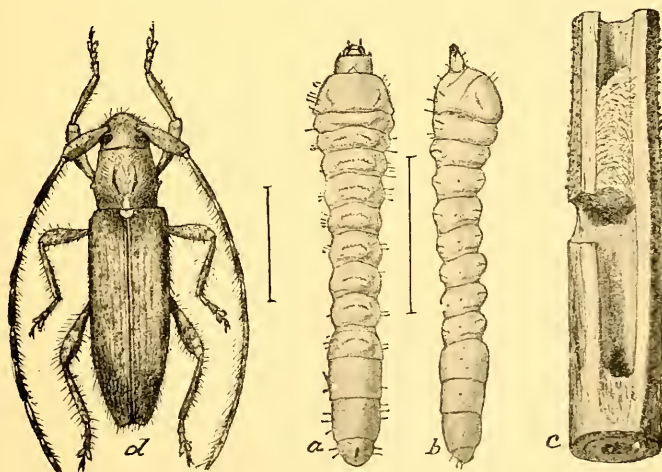


FIG. 27.—Cotton stalk borer (*Ataxia crypta*): a, larva from above; b, larva from side; c, tunneled cotton stalk showing exit hole; d, adult beetle—all enlarged except c (original).

the stalks of cotton, and that is the long-horned beetle known as *Ataxia crypta* (fig. 27). It is occasionally mistaken for an enemy to the plant,

but investigation has shown that it lays its eggs upon, and its larvæ bore into, only such stalks as have been damaged by some other cause, such as rust. It follows injury to the plant, therefore, rather than causes it.

INSECTS INJURING THE BOLL.

As in the case of the stalk borer just mentioned, numerous species of insects are found in damaged bolls which are the result, rather than the cause, of the damage. Several little Nitidulid beetles are found in such injured bolls, and a number of other insects have been sent to the Division of Entomology of this Department from time to time with the

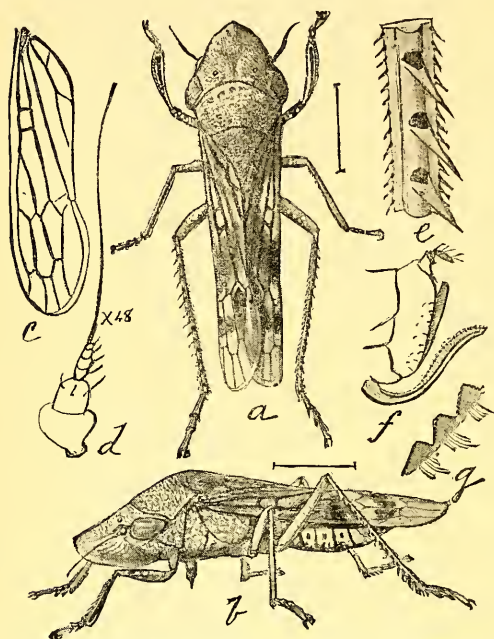


FIG. 28. —*Homalodisca coagulata*: a, adult female seen from above; b, same, side view; c, venation of forewing, enlarged; d, antenna; e, section of hind tibia; f, female genitalia, still more enlarged; g, serrations of ovipositor, still more enlarged (from Insect Life).

statement that they threatened damage to the crop. Among these the larva of a little weevil, *Aracocerus fasciculatus*, deserves especial mention for the reason that it so closely resembles the larva of the Mexican cotton-boll weevil. In fact, the larvæ of both species are found living in the same boll. *Aracocerus fasciculatus* is a cosmopolitan insect living in the pods of various plants, among others in those of the coffee plant in Brazil, but is never known to attack healthy plants. The perfect weevil is also among the various insects which are mistaken by the planters for the Mexican cotton-boll weevil, but its very short and blunt beak should at once distinguish

it from the latter species. Aside from the true bollworm, several of the caterpillars found upon the plant will occasionally gnaw the bolls, but this gnawing is in general incidental to their work upon the leaves. One of these is a leaf roller, the larva of *Platynota sentana*, which attacks the forms and squares, much like the young bollworm, afterwards feeding upon the leaves. A congeneric species (*Platynota rostrana*) also bores into the young bolls. The reddish larva of a little Tineid moth belonging to a group mostly composed of leaf miners, and known as *Batrachedra rileyi*, is often found in the young bolls, and is generally believed by planters to act independently of bollworm damage. This statement, however, has not yet been satisfactorily substantiated so far as it refers to the bolls. In the young squares, however, the active little reddish larva of this *Batrachedra* is very often found as unquestionably an original inhabitant, and it undoubtedly frequently

causes quite an extensive shedding of the squares. This, however, occurs only in the spring, at a time when there is a surplus of bloom and when many squares can be spared without great reduction of the crop. Later in the season the *Batrachedra* larva is found boring in the unopened flower heads of various weeds.

There is a class of damage to the bolls which is known to planters as "sharpshooter work," which is mainly caused by the punctures of a leafhopper known as *Homalodisca coagulata*.¹ The insect is most abundant from the first of June on through the season. Prior to the first of June it seems to prefer the young growth and foliage of poplars and other trees which may grow in the immediate vicinity. Where sharpshooter work is prevalent in the cotton field, year after year, and the trees which harbor the insects can be found in the early part of the

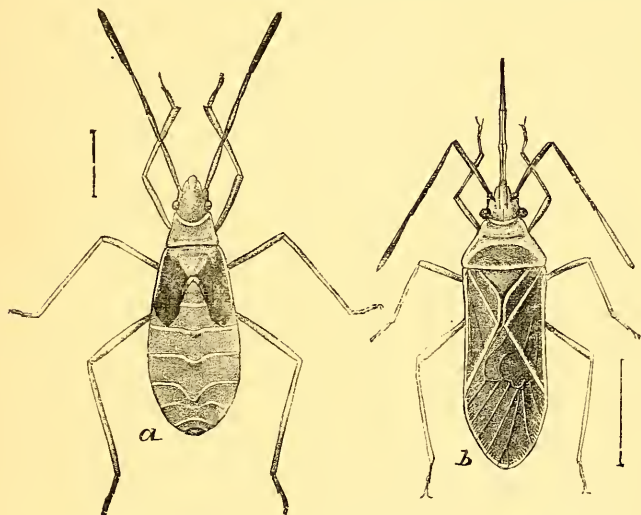


FIG. 29.—The red bug, or cotton stainer (*Dysdercus suturellus*): a, pupa; b, adult—enlarged (from *Insect Life*).

season, a single application of kerosene emulsion to the lower parts of such trees or scrub growth might be made to advantage in the month of May.

An insect which at one time did very considerable damage to cotton bolls, particularly those which were far advanced or had burst, is the red bug or cotton stainer, *Dysdercus suturellus*. This insect was never prevalent except in Florida, Georgia, and neighboring portions of South Carolina and Alabama. It is probably a West Indian species. Of late years, and more especially since cotton culture in Florida has given place to extensive orange culture, it has largely transferred its attention to the orange fruit.² Earlier generations of this insect damaged the bolls by puncturing them and sucking the sap, causing them to become diminutive or abortive. Later, however, they entered open bolls, puncturing the seed and damaging the fiber by their yellowish excrement. These stains were indelible and greatly depreciated the

¹ *Insect Life*, Vol. V, pp. 150-154.

² *Insect Life*, Vol. I, pp. 234-242.

value of the cotton in the market. The indelibility and beautiful color of the stains at one time suggested the use of the insects in making dyes. Experiments showed that the entire substance of the insect could be converted into a rich orange-yellow dye, which could be readily fixed upon woollens or silks by the alum mordant liquor, and that an ochreous yellow lake could be made from them by precipitating the coloring matter with gelatinous alumina. There has been, however, no commercial adoption of the results of these experiments.

The best remedy against this species is suggested by the fact that in winter it will collect in numbers on piles of cotton seed, which can then be used as traps and the insects destroyed by the application of hot water.

THE HANDLING AND USES OF COTTON.

By HARRY HAMMOND.

STALKS.

The stubble left on an average acre after the cotton has been picked weighs about 850 pounds, and where a bale to the acre is made more than three times that much. The leaves, however, will have been killed by frost before the picking season closes, and will have fallen from the stalks, so that 200 pounds must be deducted on this account. Many of the pods or capsules which held the cotton will also have been broken off and scattered. The stalks, roots, and capsules standing on an acre that produces one-third of a bale will be 600 pounds. Where the cultivated land is fenced, it is the practice to turn the stock in to pasture on this stubble. They strip off the limbs and pods, so that by the first of February there is nothing left standing but the bare stalks, which have been rendered hard and brittle by the cold. Cattle feed with avidity on cotton in all stages of its growth, and until the weather has left the dead stalks dry and unpalatable. The composition of the stalks as a feeding stuff may be stated as follows: Water, 10 per cent; ash, 5.23; protein, 9.54; cellulose, 40.77; nitrogen-free extract, 32.63, and fat, 1.83. This places it as a feeding stuff in the group of coarse, dry fodders, such as cornshucks, corn stover, and rye, oat, and wheat straw. If gathered early and chopped up, it would grade with cotton-seed hulls, having more protein but less fat.

Other uses have been proposed for the stubble. A process for decorticating the stalks and roots and extracting fiber from them has been patented. The decorticating machine, consisting of two grooved-iron rollers, rotating in a peculiar way above a trough containing water, is worked in the cotton field, where the stalks may be fed to it without the cost of transporting this bulky material. The bark is separated and delivered by itself, and the remainder of the stalk is ground into a coarse-grained pulp. Five tons of stalks yield 1 ton of bark, which is either baled or carried in bulk to the machine for extracting the fiber. A ton of bark gives 1,500 pounds of fiber, which is extracted at a cost of 1½ cents per pound in the actual experiments. With more complete arrangements this cost would be very greatly reduced. The fiber has been made into bagging for cotton bales, pronounced by dealers in that article to be of first quality. It might also be utilized

in the manufacture of carpets, rugs, etc.¹ An important point to be determined is whether the residue, after the bark is removed, can be used as stock feed. If fed as it comes from the decorticator, it would seem well adapted, by the admixture of cotton-seed meal, for this purpose; but it is not known whether the water used in the process will prevent it from being stored for future use. If it could be so used, then every bale of cotton would yield in the stubble a by-product of 1,440 pounds of coarse fodder and 270 pounds of fiber, sufficient to cover 20 bales of cotton.

SEED COTTON.

STORAGE.

After cotton was picked it was the custom in earlier days to store it for a longer or shorter time in houses built for this purpose in the fields. These cotton houses are no longer to be seen, except some small ones with a capacity of 2 to 3 bales of seed cotton, in the fields allotted to small tenants and croppers in the Western States. These houses had replaced the pens in which cotton was once kept exposed to the weather until time could be spared to move it to the gin. Except occasionally in Texas, cotton is no longer left in the field after being picked; there the very dry seasons render such exposure less injurious than it would be elsewhere. But even there cotton will more frequently be found stored in a covered wagon in the field until the wagon is filled and ready to be carried to the gin. Outside of the damage that would result from the greater rainfall, this practice could not be followed in the eastern portion of the cotton belt, on account of the stealing which would occur if cotton were left exposed in this manner. So great has this evil been at times that several States have found it necessary to prohibit the sale and purchase of seed cotton, or to restrict it to the hours between sunrise and sunset, to prevent its being done under the cover of night. By storing the green cotton in bulk a slight heating was produced, which caused the oil contained in the seed to impart a creamy glossiness to the fiber. This heating, carried to a certain point, seems to develop the oil in the seed, and oil-mill men find that they can obtain more oil from seed so treated. Platforms called arbors were once built, on which the cotton was spread out in the sun to absorb this oil and to dry, and it was not considered ripe for the gin until the seed would crack and not mash between the teeth. Hands were employed to pick it over and free it from the parts of leaves, stems, bolls, and stained locks left in it by the pickers. Except in the case of high-priced Sea Island cotton, all this has been abandoned as insufficiently remunerative. The large piles of bolls and fragments of stalks to be observed at the western oil mills that are taken from the seed in cleaning

¹The preparation of cotton-stalk fiber, however, has not thus far proved practically successful, owing largely, if not entirely, to the difficulty of devising a machine that will satisfactorily work up the rough, irregular material. See U. S. Dept. Agr., Office of Fiber Investigations Rpt. 6, p. 17.

them testify to the careless picking and rough handling of the seed cotton. This does not, however, seem to diminish in any degree the value placed upon the lint, for, as a rule, the western staple is graded high. The moisture in the seed of the first pickings is much complained of by the manufacturers of oil, as its drying out causes a considerable shrinkage in weight. A similar objection does not apply to the lint. The draft of air from the gin dries it so completely that the subsequent loss in weight is very small. The cotton grower sometimes finds that he does not recover in the seed and lint that comes from the gin the original weight of his seed cotton by as much as 10 per cent. In other words, 1,500 pounds of seed cotton, when green, is known to have lost something over 150 pounds in being ginned. Some of this loss may be due to the impalpable dust that was blown off, but the bulk of it is caused by the moisture in the lint that is dried out by the blast from the gin. It is claimed by cotton buyers that there should be a concession in price on account of loss of weight from drying out in cotton offered for sale early in the season. The fact above stated would show that there was little ground for this demand. As further evidence of the slight loss occasioned by drying out, it may be mentioned that 7 bales of cotton, weighing at the ginhouse 3,781 pounds, weighed 3,741 pounds after nineteen months' storage. The loss, therefore, was less than 1 per cent, or less than one-third of a pound per month, notwithstanding that samples had been repeatedly drawn from them. Practically this amounts to no loss, and ginned cotton under ordinary circumstances is one of the least perishable crops. The allowance made in the guaranty of weights by the New York Cotton Exchange may be considered ample. It is half a pound to the bale a month for twelve months.

Of late years the effort has been to carry the cotton to the gin as rapidly as possible, and to put it on the market with the least delay. The rate at which the crop is ginned and brought into sight will be seen from the following table.¹

Average percentage of the cotton crop brought in sight at the end of different quarters of the cotton year.

Period.	First quarter. Sept. 1 to Dec. 1.	Second quarter. Dec. 1 to Mar. 1.	Third quarter. Mar. 1 to June 1.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1881-1883	45.7	85.1	97.1
1884-1886	52.9	90.6	98.1
1885-1888	52.9	90.3	97.1
1889-1891	51.6	87.9	97.9

The rapidity of the movement of the crop would be more marked if figures for an earlier date were accessible, especially if they dated back to the time when transportation by wagons was the main reliance.

¹ Condensed from U. S. Senate Report No. 986.

As it is, the increase in production in recent years has gained somewhat on the growth, great as it has been, of railroads, and the larger crops come somewhat more slowly into sight on this account. By far the larger part of the crop, however, has passed from the ginnery by the last of December, and an enumeration of the work done at that date would give a very complete basis for an estimate of the crop.

GINNING.

The handling of cotton in the field and thence to the gin was formerly neater than it is now and the ginning also was in several regards better done. The different pickings were ginned separately, each picking on the large plantations being sufficient to make a run for the gins, and the different grades of cotton were thus kept distinct. The subdivision of farms has changed this, and led to conditions not very dissimilar to those described by Dr. Watson Forbes in his report on gins in India. He says:

The smallness of the farms in India, as compared with the American cotton plantations, is at the root of the evil. In India there are few ryots (and the number of cotton growers in the cotton belt of this class have grown and are rapidly growing much fewer) who can produce at one picking as much even as one bale of cotton, each bale being made up of cotton produced by several ryots. It is clear that under such circumstances the difficulty of producing cotton of uniform quality must be immensely increased.

As a consequence, says Forbes, "the loss occasioned by cleaning the impurities from India cotton was four times as great as from American uplands."

In the old ginhouse the lint was blown from the gin into a spacious lint room, where another separation took place, the dust-laden, and consequently heavier, lint falling nearest to the gin, while the cleaner and lighter flocks were thrown to the farther side. The distinction between these piles was carefully observed in baling the cotton.

The devices for separating the lint from the seed are of two classes. The first class is known as roller gins, the other as saw gins. The roller gin is the most ancient. It was used from the earliest times by the Hindoos. In its simplest form it consists of a flat stone, on which the seed cotton was placed, and a wooden roller, moved by the foot, was employed to press the seed out. To this day two small rollers, a foot long, one of wood and the other of iron, geared to move in opposite directions and turned by hand, are used in India to separate the seed from the fiber. The task is 5 pounds of clean cotton a day, and the woman who performs it receives a daily wage of 5 cents. In Sicily, also, two grooved wooden cylinders, turned by hand, are still used to pinch out the seed. In the Amoy district of China cotton is said to be cleaned by means of a heavy wooden bow suspended from a bamboo frame on the shoulders of the operator, who feeds the cotton along a board with his right hand and with his left strikes it with the string of his bow, cleaning from 50 to 100 pounds a day, at a wage of 10 cents. The

combination of the roller and the bowstring beater may be observed in certain of the modern improved roller gins used for cleaning the long-staple Sea Island cotton. The seed cotton is fed on a table to a leather roller (preferably walrus hide), the roughness of which engages the fiber, while a steel plate in close juxtaposition to the roller prevents the passage of the seed and a rapidly vibrating blade knocks them out. The cleaned seed fall through interstices in the table, and the lint is delivered on the farther side of the roller. Only cotton with naked seed has been successfully ginned in this way, the down on ordinary upland seed causing them when agitated to adhere to each other and prevents them from falling through the openings on the table.

The construction of the roller gin has undoubtedly been greatly improved in recent times, especially as regards the ease with which it is worked and the quantity of cotton it cleans, but it is doubtful if the quality of the product is any better than it was in those ancient days when the Hindoos extracted with it the delicate fibers with which they made the wonderful tissues called the "woven wind."

The saw gin works on the other plan. The seed cotton is held in a box, one side of which is a grate of steel bars or ribs. Through the intervals of the grate a number of thin steel disks notched on the edge and mis-called saws rotate rapidly. The notches or teeth of the saws engage the fiber and pull it from the seed. The seed as they are cleaned fall to the floor through a slit below the ribs. Behind the cylinder holding the saws is another and a larger cylinder (the brush) filled with bristles in contact with the saws. Both cylinders rotate in the same direction. The brush sweeps from the saws the fibers they have detached, and the draft created by the rapid revolutions of the two cylinders blows the lint out to a distance of 20 to 60 feet from the end of the gin, opposite to the one into which the seed cotton is fed.

The defects of both methods of ginning are much the same. They fail to clean the lint thoroughly of foreign substances, such as dust, fragments of leaves, etc. Some of the seed, especially the immature seed known as notes, pass through with the lint. The fibers may be strained, weakened, or even broken, or what is fully as bad, crimped and knotted (termed neps or naps) by improper force used in their removal. From all these causes a large amount of waste is always found in ginned cotton. The Willimantic Thread Company estimated that their comber removed on an average 20 per cent of such waste from the high-priced Sea Island cotton used by them. According to the report on textiles by the Commissioner of Labor (1891), the percentage of waste in the mills making returns varied from 12.78 to 22.87. For 32 Northern mills it averaged 18.49 per cent, and for 25 Southern mills the average was 16.52 per cent. The difference is probably due to injury to the fiber by being compressed for transportation. The waste from yarn to the finished product is stated as 4.81 per cent.

One of the important prerequisites for improvement in ginned cotton

is some more accurate method of determining its quality and a willingness on the part of purchasers to pay the difference between fairly and thoroughly well-handled cotton. Notwithstanding the numerous grades in which cotton is classified, their determination is practically a rule-of-thumb matter, and samplers will be found to classify and price the same sample very differently. A few ounces out of a 500-pound bale is taken in the hand, opened, and the fibers pulled out between the thumb and forefinger, and the classification decided. For many points it is sufficient; the length of the staple is observed in a general way, its color, its strength, and its freedom from dirt and, so far as the sample goes, from motes and seed and leaf. The sampler knows that there are severe laws against fraudulently packed cotton; that the contents of the bale will not differ widely from the sample he has examined, and if it should, that the marks on the bale will enable the purchaser to trace it back to the producer and make reclamation. Nevertheless, no sampler will venture to say whether the bale he has examined will suffer a waste of 10 or of 25 per cent from short or weak fibers, dust, motes, or neps. The experience of many farmers has convinced them that they get as much in the market for the closely ginned short fibers and the dust as they do for good staple, and they object to having these impurities removed. The very loose methods used by purchasers in determining the value of lint cotton is illustrated by the statement of a large manufacturer, who had had some years' experience in disposing of Florida long staples. He says:

Some of it was saw ginned and some of it was roller ginned. The roller ginned retained all of the trash and some of the seed. The saw ginned was free of seed and every way cleaner than that ginned on the roller gin. Still, that ginned on the roller gin sold for 6 cents per pound higher. I argued the point with the buyers, affirming that the saw ginned was not cut and was really the most valuable on account of its freedom from seed and trash, and proved it to them with the microscope. Their only reply was, "We think you are right, but our orders are to pay so much for that ginned on the roller gin," and they acted as per orders. I wrote to my customers these facts. Their objection to the roller gin was that it was too slow, and they fell upon the plan of using the saw gin, and after ginning to pass the lint through a whipper, which only tangled up the lint. The whipper gave it the appearance of having been ginned on the roller gin (except the trash and seed), and the buyers took it as roller ginned and paid the higher price for it.¹

In the days of the large cotton plantations much cotton was better handled than it is now. The packages were smaller and neater. It

¹In a paper entitled "Treatise upon the cotton fiber and its improvement," submitted at a meeting of the New England Cotton Manufacturers' Association at Atlanta, Ga., October, 1895, Edward Atkinson, referring to the use of the saw gin, says: "We take three-quarters of the life out of our cotton by our murderous method of treating it. We nearly wear it out before we begin to weave it." And asks, "Would it not be better to nip these fibers between two elastic rolls, to draw them away from the seed without upsetting, tangling, and cutting them?" He argues at length in favor of the more extended cultivation of long-staple varieties, and of more earnest efforts to improve the roller gin, using the latter in connection with the recently introduced cylinder press (see p. 362).

was picked with greater care. The name of the grower in full, with that of the plantation on which it was grown, was put on each bale, and was a guaranty of its quality. In addition, other brands were added, indicating the exact quality of the cotton, which was sold sometimes by their brands as wines are. Of course, with the increased multitude of small cotton growers this has passed away as impracticable. After being stored and sunned as described above, the cotton, when necessary, was often passed through machines known as openers, whippers, and thrashers, in which the cotton was tossed about and subjected to a draft of air to remove trash and dust. The separation of the clean and dusty cotton in the large, old-fashioned lint room has been referred to. The clumsy old compass press, where an elm-wood screw 2 feet in diameter and 12 feet long was run down on the cotton by three mules attached to levers, with a sweep of 30 feet, made a neat package, but one open to the objection of being bound in ropes. In case of fire the ropes would burn, and the bale, bursting open, would scatter the fire. The old gins were run by horsepower or by water; steam was not used. They ginned slower. As a result, except in very wet cotton, the fiber was never cut or broken; nor was it crimped or knotted by the impact of the saws as when the cylinder rotates at a speed greater than 400 revolutions per minute. The movement of the saws through the seed cotton held by the grate in the roll box, imparts to it a rotary motion in the direction opposite to that in which the saws are moving. This is called the roll. A low speed gives a loose roll; a high speed gives a closer and more compact one. The higher speed and closer roll does the largest amount of work, and by cleaning the seed more thoroughly increases the quantity of the product. At the same time, this high speed strains and breaks more of the fibers, adds by its close cleaning to the number of short fibers, and often nips off fragments of the seed, all of which goes to swell the percentage of waste. The motes, or immature seed with lint attached, pass through the breast with the lint, the spaces between the ribs not being close enough to prevent the passage of such small bodies. They are swept from the saws by the brush, but their exit from the gin with the lint is prevented by an adjustable board below the brush that opens or closes the aperture through which the air is sucked in by the revolution of the cylinders. If the opening is large, the great draft carries the motes through with the lint; if small, the draft is less, the heavier motes fall under the gin, and only the lighter lint passes on.

With the subdivision of farms an almost new industry was developed in the way of toll gins. The old plantations had each its own ginhouse, but the small farms could not bear the expense of such a plant, and public gins became a necessity. They sprang up everywhere, and, as is usual in the trial of new things, were cheaply and very poorly constructed. The first thing to go was the expensive old compass press. It was replaced by hand-lever presses of many varieties. The old lint

room soon followed. The condenser could be used in a cheaper building, reduced the labor of handling and the risk from fire, and it was substituted for the lint room, though it did not improve the quality of the product. Steam engines were used, as more convenient than water power and as doing more work than horsepower. Very soon it was thought that ginning could be accomplished like wheat threshing—by portable machines. A number of plants, consisting of a portable engine and gin, were tried for a year or two. The cost of maintaining teams to transport the outfit to where only a few bales at a time were ready for the gin, and the difficulty of arranging for a supply of wood and water at the different farms, as well as interruptions of work done in the open air by wet weather, made portable gins unprofitable, and they have been abandoned.

The small and cheaply constructed ginhouse, and the use of steam in connection with it as the motive power, has been a prolific source of much loss by fire. Like most other establishments engaged in manufacture, the tendency is toward their consolidation and enlargement. Ginneries, with a capacity of 50 to 75 bales a day, are becoming quite numerous. There is one near Waco, Tex., which it is claimed will turn out 250 bales a day. The obstacle to their enlargement is the difficulty of transporting such bulky material as seed cotton, requiring three times the space to hold it and three times the power to move it that lint cotton does. In a district producing 65 bales to the square mile, the maximum haul to keep the Waco ginnery in full work would be about 10 miles. The average haul would be much less. Where facilities for ginning and marketing are to be had, cotton in the seed is now not unfrequently hauled 11 and even 12 miles. Wagon transportation to market for the lint is found cheaper than railroad carriage up to 20 to 25 miles.

In the gin itself no radical change or improvement has taken place since the days of Whitney, its inventor. The material used and its construction are better, but the recent improvements have all been in the superior handling of cotton at the gin. The system of elevating the cotton by suction has been used about fifteen years, and has been greatly simplified and improved. A fan blower draws a current of air through a wood or metal flue, sucks the cotton up from the wagon or bin in which it has been stored, and delivers it to the gin. At first the cotton was allowed to pass through the fan on its way to the gin. The friction in the fan ignited the cotton, and fires occurred. Now the fan is placed on the farther side of a receiver, where a screen stops the cotton, but allows the air, with the dust it has collected from the cotton, to pass on and out of the house. From the receiver the cotton is delivered by a revolving roller onto a belt, which deposits it in the feeders of the gins, or the belt may be dispensed with and the cotton delivered into receptacles of sufficient capacity over each gin, and from there it is automatically deposited in the feeders of the gins. A single flue for all the gins, or sometimes a flue for each gin, made of wood or

metal, conducts the lint moved by the blast from the saw and brush cylinders of the gin to a condenser. During its passage through this flue the lint is treated in much the same way as it was in the old lint room. The current of air straightens out the fibers crimped by the ginning, the heavier sand falls into a pocket arranged to receive it as the lint rises to the condenser, and the lighter dust is blown off and escapes from the building through flues issuing from the condenser. The seed meanwhile fall from the gin into a screw conveyor (preferably with a perforated bottom, to allow the escape of sand), and is either delivered directly to the wagon or into the seed house or dropped into a flue from the blower, which transports them wherever it is desired. From the condenser the lint falls into a press, where a plunger, worked directly by steam or by other power, presses it down as may be required. When the box is filled it is turned round over the screw and packed, while another box, turned under the condenser by the same movement, continues to receive another bale. The cotton is packed by a screw, by steam, or by hydraulic pressure, according to the character of the outfit. The battery of gins, generally four in number for each condenser and press, stand close together, and may be stopped instantly by a hand brake on each, which slackens the driving belt. Under this system the ginhouse is free from dust and lint, a great nuisance and greatly increasing the risk of fire in the ordinary ginhouse. All the operations are carried on, as it were, under cover. The observer might fail to see cotton anywhere until he saw the lint sliding from the condenser into the press. Steam extinguishers and water sprinklers are found in well-arranged ginhouses. Seed cotton—and there need never be as much of it as a bale in such a ginners, so quickly is the work of receiving and cleaning it dispatched—while easily ignited, merely flashes over, and the fire goes out. When orders were issued during the war to burn cotton the task was found to be not an easy one. The only way to accomplish it was found to be to set fire to the building, and even then if there was a large pile of cotton much of it was left unconsumed. It is different with lint cotton. When once on fire it will burn and smolder indefinitely. A burning bale when thrown into the water will float and burn until all of it is destroyed. But under this system the lint passes at once into the press, and should it catch fire there the plunger that tramps in the cotton is let down on it and smothers the fire until steps are taken to remove and extinguish it. Risk from fire is for these reasons at a minimum. If the gin can not clean the cotton as it is hauled in, it is usual to store it in a separate building situated at some distance (100 feet or more) from the ginhouse. The bins in which the lot of each owner is placed are each connected with the flue of the fan blower and may be sucked into the gins as required. These improvements have greatly reduced the labor required to operate a ginners. Under the old methods the cotton was unloaded in baskets and elevated to the gin by hand. This employed

the time of one hand for each gin. A ginner was also required for each gin, and another hand to put the cotton in the press and attend to the packing. Three hands to the gin, say of 60 saws, making 400 revolutions per minute—the speed producing the best staple—would turn out 6 bales in a day of 10 hours. With the suction elevators the same number, with much less labor, would attend 4 or 5 gins and turn out 24 to 30 bales in the same time.

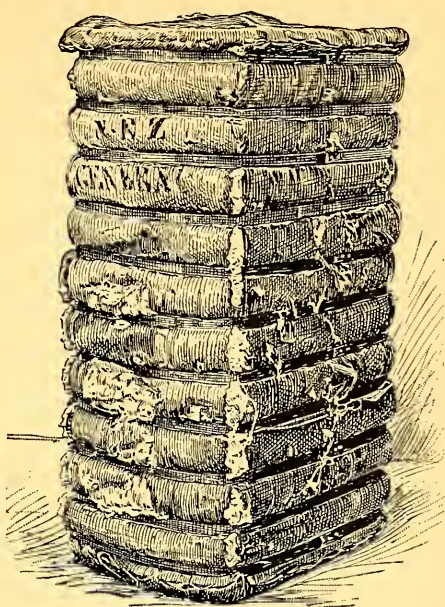
BALING.

While the standard bale is 54 by 27 inches and is intended to contain nearly 500 pounds on the average, bales actually vary greatly in size and in every dimension, and to a still greater degree as regards the density of their contents. This adds to the difficulty of storing them on shipboard and to the expense of handling and transportation. Loosely packed bales are liable to serious damage from rain, to which they are always more or less exposed. The covering is of such coarse material that dust and rain easily penetrate it and soil the cotton, while the size of the bale is so great that it has to be rolled about by iron hooks devised for the purpose. The covering is torn in this rough handling, more or less cotton falls out and is lost, and the exposed lint is fair game for any stray spark that may come in contact with it (fig. 30). It was thought that these evils would be remedied by putting up the lint in smaller, more compact, and more neatly covered and protected packages. Some years ago it seemed that the Dedrick perpetual press had fully met all of these requirements. The cotton was put up in bales of 100 pounds and of a density nearly equal to that obtained by the compresses. It was packed one section at a time, each section being subjected to exactly the same pressure, which preserved the staple. The Willimantic Thread Company testified that "the cotton so compressed made less waste at the picker, in the cards, and in the combing machine" than the long-staple Sea Island cotton, which was always put up in loose, round bales packed by hand to avoid injuring the delicate staple. The press was used to some extent, and the New England mills paid a higher price for cotton packed by it. But dealing in these bales was only practicable directly with the mills, where, in addition to the superiority of the staple, their storage and handling were found easier and more convenient. They were not salable in the open market. The practice there was based on the large bale. Numerous charges attached to it as a unit, and the change involved was too great a revolution in settled customs. It is noteworthy that with the increase of cotton production the size and weight of the bale has grown. The American bale has grown from 300 pounds to 500 pounds. In States producing the largest crops the bales are heaviest, and even in the same States the weight varies as the yield of each season has been large or small. The Egyptian bale averaged only 245 pounds in 1855. With the greatly increased production it weighed 714 pounds in 1892. In Peru, Brazil,

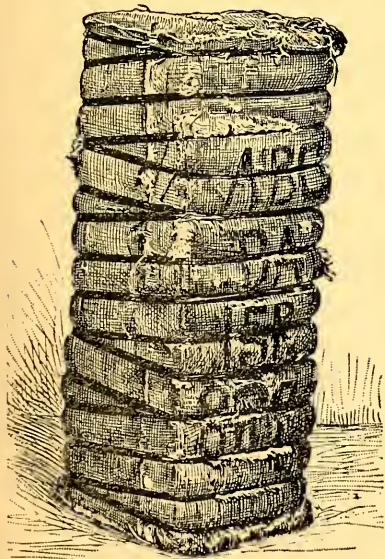
and Persia the bales ran from 175 pounds to 220 pounds. In Asiatic Russia they ran from 250 pounds to 325 pounds. India forms an excep-



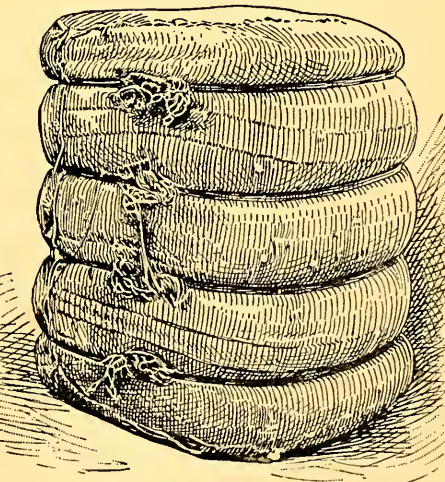
American bale.



Egyptian bale.



Indian bale.



Turkish bale.

FIG. 30.—Appearance of different kinds of cotton bales on arrival at Trieste, Austria-Hungary (from cuts furnished by the State Department).

tion, the 392 pounds, which is the average now of those bales, being only 10 pounds more than the average weight in 1856. The size of the

Indian bale is much smaller and its density much greater than that of the American bale. It weighs 39 pounds to the cubic foot, while compressed cotton in American bales is rarely 35 pounds, and frequently only 25 pounds. The bagging and ties in which the cotton is put up is a source of loss to the farmer, though he seldom realizes it, and when he does is at a loss how to avoid it. It costs about 60 cents a bale and adds 21 pounds to 24 pounds to its weight. No distinction is made in the home market for any difference in the weight of the covering. A bale having 30 pounds of jute and iron on it sells at the same price per pound as one that has only 18 pounds of such tare. This causes the farmer to believe that the heavier covering is more profitable. But in Liverpool, where the price of cotton for the world is in large measure established, a deduction of 6 per cent is made for tare. That is to say, 24 pounds are deducted from a 400-pound bale and 30 pounds from a 500-pound bale. Not, indeed, from every individual bale, but a discount in the prices of cotton to that extent is made the rule with their purchasing agents in this country. The tare deducted in this way amounts for the present to a weight equal to that of 500,000 bales of cotton, worth, even at the low prices of this crop, \$14,250,000. The percentage of the weight of covering to that of contents being greater for a small than it is for a large package, the loss falls less heavily on the first than it does on the latter, and this would tend to make the charges less on a light than they are on a heavy bale. However, there are such a number of other charges that attach to the bale that this is not sufficient motive for reducing its size. Taken altogether, it is generally admitted that the American bale is the clumsiest, dirtiest, most expensive, and most wasteful package in which cotton, or in fact any commodity of like value, is anywhere put up. It has no friends either among manufacturers, buyers, shippers, insurers, or producers. Custom seems alone responsible for this incubus on the industry. Among other efforts made to remedy its defects, the Bessonette system of baling requires mention. The Bessonette press is a self-feeding press which receives the bat of lint as it comes from the condenser upon a spool between two heavy rollers. The friction of the rollers rotates the spool and winds the bat upon it so tightly as to press out nearly all the air and to form the roll into a package with a density of 35 pounds to the cubic foot and of uniform size and shape throughout. The pressure employed is only 25,000 pounds to the bale, against 5,000,000 pounds by the compress. In the Bessonette, as in the Dedrick press, the pressure is exerted equally upon each separate portion of the cotton as it is subjected to the power. In the compress, one sudden blow of tremendous force acts upon the entire bale and drives the mass that stood from 27 inches to 40 inches deep into a space of 7 inches. It is true that when the pressure in the compress is taken off the elasticity of the fiber causes the bale to swell up again to a thickness of 12 inches to 18 inches, but the injury, whatever it is, has been already done, and the enlargement

only gives a misshapen, turtle-back package, which has to be reduced again by jackscrews in the ship's hold. The variations in the length and width of the bale remain unchanged by the action of the compress, and this again adds to the difficulty of compact loading. The Bessonetette cylindrical bale (fig. 31), on the contrary, is of uniform length, with a diameter of 14 inches to 16 inches. The bales are covered with cotton cloth. The ends are capped with the same material, held in place by a small hoop of wire. No ties are used, nor are they necessary, for the bale retains its shape without them. The tare is only $5\frac{1}{2}$

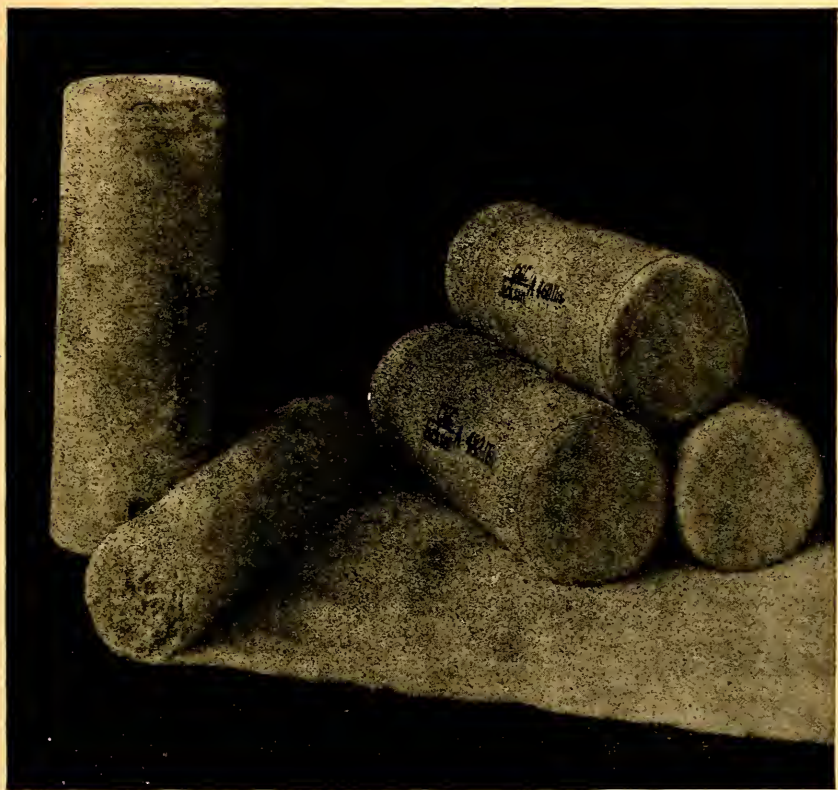


FIG. 31.—The Bessonetette cylindrical cotton bale.

pounds against the 30 pounds now charged on the average bale, and the material of which it consists will have a value when the bale is unwound much greater than the iron ties and jute now used, which can only serve as waste. The bales may be sampled in the usual way, but much more easily by removing the caps from the ends, when the quality of each separate layer, just as it comes from the condenser, may be inspected, thus rendering mixed or fraudulent packing impossible. A striking feature in these bales is that they are practically fireproof. Experiments were made in Waco, Tex., on November 16, 1894, in the

presence of a number of insurance men. A hole was cut in the covering and some of the loose lint puffed out. A match was applied, and the lint blazed up and then went out, as it would have done if laid upon a log. The covering was ripped half the length of the bale and a torch applied with the same result; the loose cotton burned without igniting the bale. The end of the bale was opened and fired; it burned an inch or two deep, and the fire went out. All the covering was then taken off and loose cotton piled upon the bale and set on fire. It blazed up, and when the blaze was at its height the bale was rolled out of the flames and turned over a time or two to smother the blaze. One layer of cotton was rolled off from the outside of the bale and the balance was found absolutely free from fire. The air is so completely pressed out from the lint that it does not support combustion. The experiment entitles the bale to the appellation bestowed upon it by Edward Atkinson of the "underwriters' bale." There is a saving in ginning and baling by this method, and a conservative estimate places the saving on compressing, handling, insurance, and transportation at \$4.25 a bale, which, on last year's prices, is fully 20 per cent of the value of a bale. Such processes will encounter much opposition from the dead weight of existing methods and from the large capital invested in their operation, but in the long run the saving and security effected by them ought to secure their adoption. The Southern cotton mills will not care so much for this; they do not want and do not use compressed cotton, preferring to get it directly from the producer. While they benefit by the reduction of the price which discounts the tare charged abroad, they are able to dispose of many of the iron ties and nearly all the bagging to the cotton growers, to be used by them for the same purpose again.

Large ginhouses, with improved methods of handling cotton, are being put up in many places in connection with oil mills. They facilitate the purchase and cheapen the cost of seed. The seed are of better quality, not having been subjected to damage from heating during transportation. Selected directly from the gin, they produce a superior oil and meal. It is thought that a whole round of operations now distributed among such a multitude of middlemen will in time be concentrated about the ginhouse, and that it will become the pivot of the whole cotton industry, from the time the raw cotton leaves the field until it is ready for the mills and the various by-products are suitably prepared for the consumer. As is now the case in many cotton-producing countries, the ginner will purchase the seed cotton from the grower, store, gin, bale, ship, and sell it. The farmer will carry back with him, besides the cash his lint sells for, the hulls and meal for his stock feed and fertilizer, and such portion of pure oil as he may need as a substitute for the hog's lard he has been accustomed to use. Thus he would accomplish at once what he does now only by several journeys and by complicated dealings with the venders of bagging and ties, fertilizers, groceries, and stock feed, and with cotton brokers.

Although the ginning and packing of cotton would seem naturally to be entitled to a position among manufacturing industries, at least to the same extent that slaughtering and packing cattle are, or grinding grain, or sawing plank, it has never been so classified. No mention of ginhouses whatever as industrial establishments was attempted prior to the Eleventh Census. In that enumeration their aggregate number is given as 1,637—a figure, however, far below the actual facts.¹ In the absence of reliable data, it can only be said that it would have required over 23,000 gins, working full time during the ginning season (which is, of course, never done), to clean the last crop, and that the cost of the plant and power to operate them must have exceeded \$30,000,000. The old cost of ginning and packing, covering not furnished, was \$5 a bale. The cost is now greatly reduced. In Texas it is a twelfth, or \$3 a bale. In some sections of the east it is as low as one-thirtieth, estimated to be about \$1 per bale, though it amounted to a good deal less than that at the last season's prices.

MANUFACTURE AND USES OF COTTON BY-PRODUCTS.

Among the by-products of ginning the notes may be mentioned. In the small ginhouses little care was taken of them. They were given to anyone who would take them away, and were used for stuffing bedding and bed clothes, making very comfortable coverings for cold weather. In the larger establishments they are passed through a machine to free them from dust, mixed with seed, reginned, and sold as an inferior staple, but yielding a notable revenue.

Of very much greater importance is the seed, which, after reserving some 7 per cent for planting purposes, are disposed of as fertilizers or sold to the oil mills.

OIL.

Oil obtained from various vegetable substances has been esteemed from the earliest times as one of the most precious gifts of nature, and its abundance marked the periods of greatest prosperity. Notwithstanding the use of cotton as a textile material in the remotest days, there is no record of oil being extracted from the seed. The Chinese and the cotton growers of central Asia have for a long time ground the whole seed in rude mills and fed the cake to their oxen. Such oil as was extracted in this rough manner was used for purposes of illumination, and very little of it was consumed as food. Among western nations, the first mention, perhaps, of cotton-seed oil is to be found in the proceedings of a society instituted in London for the encouragement of the arts, manufactures, and commerce for the year 1783. Seed from the cotton growers of the West Indies was crushed in a mill in London in the presence of the secretary of the society and the oil extracted. The result was so satisfactory that the society offered a prize of a gold medal to any planter in the British West Indies who

¹The figures of the Eleventh Census, however, refer to public ginneries, no account being taken of private establishments.

should express a ton of oil from the seed and make 5 hundredweight of dry, hard cake fit for cattle food from the residue after extracting the oil. The offer was made from year to year until 1789, when, no results having been obtained, it was discontinued. Mills, in his statistics of South Carolina, published in 1826, says that Benjamin Waring had established an oil mill in Columbia, and "expressed from cotton seed a very good oil." It was estimated, he says, that 100 pounds of seed would yield a gallon of oil, which he thought a very low estimate. He doubtless had in his mind the yield of oil from linseed, which was then known to be about 1 pound of oil from 4 pounds of seed. Analyses show that cotton seed contain about 20 per cent, or 53 gallons, of oil per ton of seed. Such a result has not yet been attained in the American manufacture of the article. The highest actual yield at the oil mills is 44 gallons, with 40 gallons as a high average. English mills, however, repress the cake from which this amount has been extracted in America, and obtain a product that is found remunerative. About 1832 a small cotton-oil mill was operated on one of the islands on the Georgia coast. Attempts were made in Natchez, Miss., two years later, to extract oil from the seed. In *Ure's Dictionary*, 1843, cotton seed is mentioned in a list of 41 plants from which oil is obtained, but no further reference is made to it. A Mr. Good engaged in the manufacture of the oil in New Orleans in 1847, and he used to exhibit a small bottle of the oil which he said had cost him \$12,000. The French made a better advance in developing the industry. From the naked seed of the Egyptian cotton they extracted oil, refined it, and used it for edible purposes. Paul Aldige, of New Orleans, visited Marseilles to study the processes employed. As a result of his efforts, the cotton-seed-oil industry was revived in New Orleans about 1855. The war checked its growth. The blockade of the ports preventing the export of the cake, it was used for fuel. The hulls, at considerable expense to the mills, were dumped on vacant lots in the outskirts of the city. The owners of cattle which grazed over these lots paid watchmen to prevent them from feeding on the hulls, fearing they would be made sick. The blockade, however, rendering forage with all other supplies very scarce, the cattle were allowed, cautiously, to gratify their predilections for the hulls, and no injury resulting, hulls became a staple stock feed.

OIL MILLS.

The growth of the oil industry was slow. As late as 1858 a list of 50 plants yielding oil, given in the *Encyclopædia Britannica*, does not include cotton. In 1860 there were 7 establishments for the manufacture of cotton-seed oil in the United States. There were 4 mills in the South in 1867, and they increased greatly in number, there being 26 in 1870 and 45 in 1880. The crude oil sold for from 50 to 60 cents a gallon, and there seemed a promise of very large profits in the business. Improvements were made in the machinery and processes and guarded with great secrecy by the parties devising them. The oil industry was at first controlled by one large company, but others soon sprung up, the

competition between which has been of advantage to the producer of seed. The annual report of the American Cotton Oil Company for 1891 illustrates the scale on which the cotton-seed-oil industry is being conducted. With a capital of \$33,761,700, it owns 72 crude-oil mills, 15 refineries, 4 lard and cottolene plants, 9 soap factories, 15 cotton ginneries, 3 cotton compresses, 2 fertilizer mixing plants, 1 ocean tank steamship of 4,200 tons and 2,300 horsepower, 355 oil-tank cars, 23 box cars, and 1 barrel car, besides products, real estate, etc. The sale of their products for the year amounted to \$23,879,400. The influence of these large companies, while sometimes complained of as arbitrary and oppressive on the whole, promoted and developed the industry.

Their numerous agents engaged in the purchase of seed educated the farmers to a knowledge of its value. They introduced on a large scale the products to consumers. They improved the methods and machinery. In a word, they cleared the ground, and now all who desire to do so may sow and reap. The following table exhibits the growth of the cotton-seed oil industry in the United States:

Statistics of the cotton-oil industry.

Year.	Estab-lish-ments.	Capital.	Employ-ees.	Wages.	Cost of materials.	Value of products.
1860.....	7	\$351,000	183	\$75,956	\$498,000	\$741,000
1870.....	26	1,225,350	644	292,032	1,333,031	2,205,610
1880.....	45	3,862,500	3,114	880,830	5,091,251	7,690,921
1890.....	119	.....	6,301	1,907,827	14,363,120	19,335,947
1894.....	252	.....	.....	.....	18,000,000	30,000,000

The great increase noted in 1894 is due in a large measure to the establishment of small mills. Their increase by the side of the large companies shows how large a part of the field well adapted to this industry remains unoccupied.

A ton of cotton seed occupies a space of over 88 cubic feet. As the smallest mills crush 10 tons of seed a day and the larger ones over 200, considerable storage room is required for this material. The seed from the whole crop is ready for the mill by the end of December, and is always exposed to damage by remaining at the gin, where sufficient shelter for it is not provided. It is a very unstable product, for even the pressure of the mass, if stored in bulk, especially if any portion of them have been trampled upon and crushed, suffices to cause heating and a rapid fermentation in the damp seed as they come from the gin, which either destroys the kernel entirely or renders it fit to produce only meal and oil of inferior quality. No plan has yet been devised to preserve them in large quantities, and rapid handling is a necessity. If transportation is taxed to move the cotton crop, little subject to damage and loss except by fire, it can readily be understood how much greater the burden must be of moving, during this same season of heavy work, this perishable commodity that is twice the weight of the lint and occupies a space 40 per cent greater. In the report of

the American Cotton Oil Company for 1893 it is estimated that the cost of the transportation of that portion of the seed crushed by the mills, and its products, by railroads and steamboats amounted to more than \$8,000,000. The mills have seed houses and scales at the railroad stations and employ agents to purchase the seed as the wagons bring them from the gin. They are stored, and as occasion offers shipped in bulk in box cars. The seed transported by water are sacked. The smaller mills obtain most if not all their seed directly from the gin by wagon.

Arrived at the mill, the seed are shovelled into a bucket elevator that empties them into a screw conveyor in the very top of the building and running its whole length. Chutes on either side of this conveyor discharge the seed into the building, wherever storage room is most available.

Below the level of the floor, and immediately under this conveyor, there is another conveyor by which the seed, as it is needed, is carried into the mill. One man will thus dispose of 30 tons in 12 hours. The seed is taken from this conveyor into an elevator, which delivers them to the boll screen. This is a cylinder revolving 20 times in a minute, with perforations sufficiently large to allow the seed to escape into a box below, while the larger impurities, such as bolls, flocks of lint, and other foreign substances mixed with the seed are poured out at the farther end of the screen. Another elevator receives the seed from the box below the boll screen and transports them to the sand screen. This is a screen or reel similar in construction to the first, except that the perforations are smaller; the seed are retained and the sand and dust sifted out from them. The clean seed pass on to a blower, where the fine dust is expelled by a current of air and the seed themselves are blown in a thin layer over magnetic plates, or bars, which attract and retain bits of metal, fragments of nails and bolts mixed through carelessness with the seed, and so far escaping the cleaning process. It is the duty of the man in the screen room to remove these pieces of iron at frequent intervals, and their quantity is a great surprise to the ginner who have handled the seed cotton. In these various processes the original weight of the seed is reduced about 6 per cent, and if they are green or damp the loss will exceed this.

Being now thoroughly cleaned, a conveyor and elevator carry the seed to the feeders of the linters. These are large gins having usually 106 saws placed much closer together than they are in the ordinary gin. A linter of this size requires a 5-horse power to move it and makes 350 revolutions per minute. It can gin 16 to 24 tons of seed in 24 hours. The short fiber or linters, as it is called, passes to a condenser, which forms it into a roll. The rolls are removed every hour and placed in a press to be baled as other cotton is. It is used to make paper, hats, carpet yarns, cheap cloth, and for most of the purposes to which ordinary lint cotton is applied, but of course commands a lower price. The delinting of the seed is necessary to remove the down, which

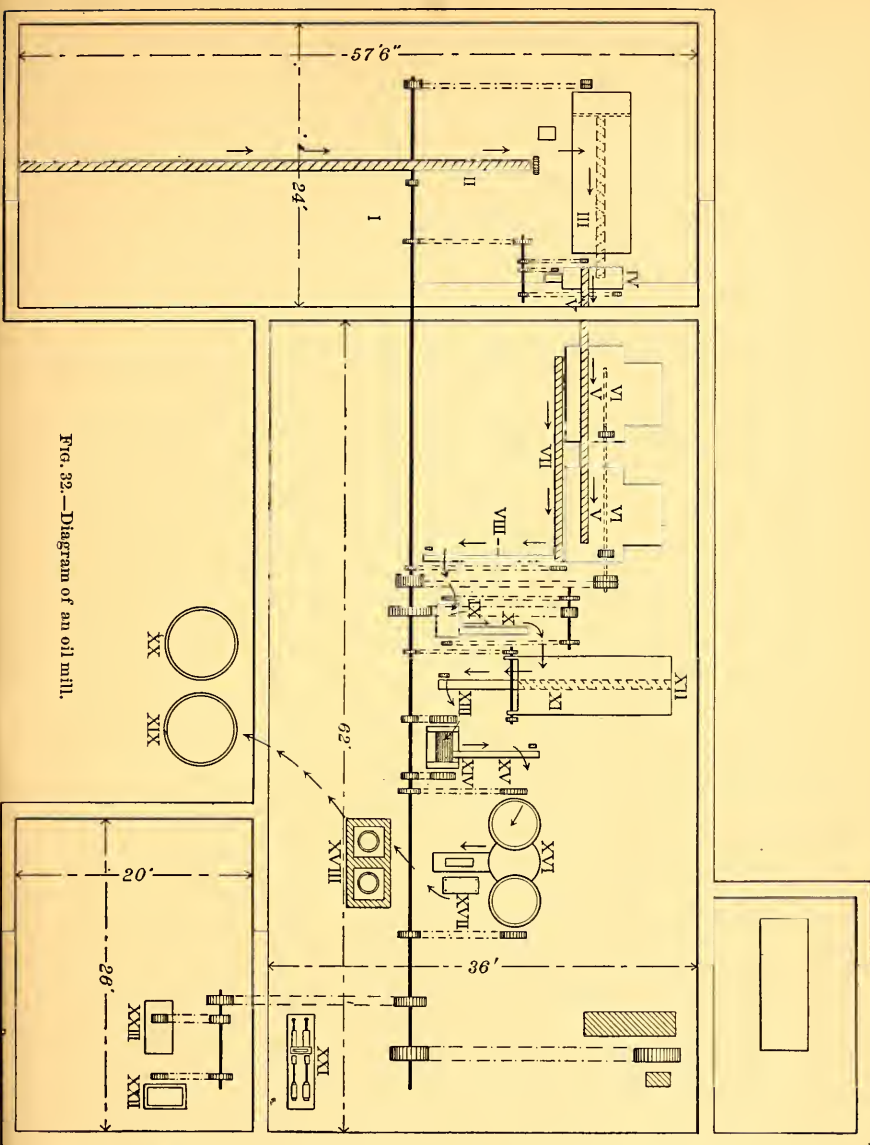


FIG. 32.—Diagram of an oil mill.

- I. Seed house.
 - II. Seed conveyor to reel.
 - III. Sand and boll reel.
 - IV. Blower and magnetic field.
 - V. Seed conveyor to delinters.
 - VI. Delinters.
 - VII. Seed conveyor from delinters.
 - VIII. Seed conveyor and elevator to huller.
 - IX. Huller.
 - X. Conveyor and elevator of meats and hulls to separator and shaker.
 - XI. Separator and shaker.
 - XII. Point of delivery of hulls.
 - XIII. Conveyor and elevator of meats to rolls.
 - XIV. Rolls.
 - XV. Conveyor and elevator of meats to heaters.
 - XVI. Heaters.
 - XVII. Former.
 - XVIII. Press.
 - XIX. Settling tank.
 - XX. Storage tank.
 - XXI. Duplex hydraulic pump.
 - XXII. Cake breaker.
 - XXIII. Mill for grinding cake.
- The arrows indicate the direction in which the materials move.

otherwise absorbs the oil and prevents it from being extracted. It also renders the seed easier to plant and improves the hulls for stock feeding.

The seed fall from the linter into a conveyor, which carries them to the huller. The huller is a strong cylinder furnished with knives inside of which a drum having another set of knives adjusted to within one to three sixteenths of an inch to the others revolves 850 times a minute. The seed falling between these knives is rapidly cut to pieces, the loose kernel or meat dropping out. A huller of medium size will work up 40 to 50 tons of seed a day.

The oil mill day is twenty-four hours, for the work goes on night and day during the season, one gang of laborers being employed during the day and another at night. This is done first, in order to handle the seed as rapidly as possible to save storage room and to avoid injury to the seed by prolonged storage, and in the second place to avoid a certain amount of loss resulting from an interruption of the cooking of the meats. The mills thus run continuously from Monday morning to Saturday night when there is a supply of seed.

The mass of chopped seed, meats, and hulls pass by elevator and conveyor to a large reel covered with screen wire, revolving 20 times a minute. The meshes of the wire are of such size as to allow the meats to fall through, while most of the hulls are retained, pass out of the tail of the reel, and are carried by a conveyor to the hull house. The hulls are so bulky as to make storage difficult. They are liable to heat when kept in bulk, but this is obviated by putting them up into small packages of 85 to 90 pounds, confined by boards and wires, having a density of 33 pounds to the cubic foot. Baling as at present practiced costs about 90 cents a ton, but the hulls keep well and are easily handled. They are sometimes pressed into sacks and preserved in that way, or before baling and sacking they may be mixed with definite quantities of cotton-seed meal, bran, cracked corn, or other feeding stuff, to be disposed of as a prepared stock food. Heretofore a large proportion of the hulls have been used for feeding the engines that supplied motive power to the mills. Their fuel value is estimated at 80 to 90 cents a ton where good pine wood is to be had at \$2 a cord or coal at \$3.50. A cord of wood is considered equal in heating power to 2½ tons of hulls, and a ton of coal to 4½ tons of hulls. This is rather expensive use to make of an article retailing at this date in some of the towns at \$8 a ton for stock food. Few articles have come to the front more rapidly than cotton-seed hulls. An English report on the oil industry in America in 1887 says there were made 175,000 tons of cake, 75,000 tons of oil, and 243,750 tons of waste. This waste was the hulls, which at a date a little anterior to the date of that report the mills were hiring wagons to haul off and put out of the way, but for which they can not now supply the demand.

As the meats fall into the box below the reel they pass on to a wire separator or shaker oscillating 250 times a minute. The short down

adhering to the hulls that remain with the meats causes them to felt or stick together in wads as they are tossed upon the shaker, and thus prevents them from falling through with the meats as they are sifted out. The naked seed of Egyptian and Sea Island cotton not being provided with this down, the meats and hulls can not be separated as thoroughly as is done with the American upland seed; as a consequence the oil and cake made from them is of inferior quality. The cleaned meats are carried by a conveyor to a set of heavy chilled-iron rollers, varying from 3 to 5 in number and from 2 to 5 feet in length, according to the capacity of the mill. The meats are evenly distributed, in proper quantity, from a hopper to the rolls, and pass in succession between each pair of rolls, whose smooth, hard surfaces and heavy weight mash them into thin flakes, crushing every oil cell.

After this crushing the meats drop into a conveyor, which delivers them to the heaters. These are large cast-iron steam-jacketed kettles provided with stirrers, which keep the meats moving while they are being cooked. The duration of the cooking varies from 20 to 30 minutes, according to the condition of the kernels and the good judgment of the cook, a human quality here called for the first time to supplement the automatic mechanism that has conducted the seed to this point through all the various processes it has undergone in its journey from the seed house. The object of the cooking is to expand the oil in the meats and render it more fluid, and to drive off the water, which not only reduces the quality of the oil but is liable to work serious injury to the expensive cloths used to envelop the cakes in the press. Very dry meats may sometimes be cooked in 12 to 18 minutes, while fresh seeds may require 45 minutes. Close to the heaters stands the "former," which shapes the meats into cakes for the press. The cakes as they come from the former are wrapped in camel's haircloth and removed by hand to the press, where they are arranged in a series of boxes, one above the other, between the plates of the press, and subjected to a pressure of 3,000 to 4,000 pounds to the square inch by hydraulic power.

The size of the press varies. One carrying 16 boxes has a capacity of 15 to 20 tons of crushed seed in a day. As the ram rises the oil is pressed out, slowly at first, but later running in streams down the press as the pressure increases. Skillful hands will charge a 16-box press in 2 minutes, and the press being allowed a short time to drain, may be run up every 10 to 20 minutes. The cakes, pressed as solid as boards, are taken from the press, stripped of the cloths, loaded upon a truck, and weighed to keep tally of the seed crushed. The weight of the cake multiplied by 2 plus the weight of the oil ($7\frac{1}{2}$ pounds per gallon) which is measured, gives approximately the weight of the seed crushed. The stripped cakes are stacked to dry. When dry, as occasion requires, they are passed through a cake cracker, which breaks them into fragments of a size suitable to be fed to a mill. The mill grinds these fragments into a fine meal, which is put up in sacks containing 100 pounds. Sometimes the meal is bolted to separate it from small pieces

of the hull, which, being tough and leathery, are not readily ground up. The oil is pumped into a settling tank, where impurities fall to the bottom, and the clear oil is drawn off into storage tanks, preparatory to being shipped. The settlings or "foots," as they are called, are thrown back into the heaters and repressed. They are also barreled and sold as soap stock. Sometimes the oil is drawn directly from the settling into the refining tank, for there are oil mill men who believe that oil is somewhat injured if allowed to stand 48 hours without being refined. In the refining tank the oil is gently heated and kept agitated by stirring and by having air thrown into it from below through a perforated pipe. It is treated with caustic soda or potash, which coagulates the impurities and causes them to sink. The oil is then drawn off, washed with water, which dissolves out the alkali, the oil floating on top, and passed through a filter press. The refining completed, it is barreled for shipment.

OIL-MILL PRODUCTS.

At one time all oil was shipped in barrels, but now only refined oil, or oil on which cheap rates of transportation are obtained, is shipped in this way. As early as 1885 the American Oil Trust introduced the use of tank cars. By 1890 their use had become general, the refineries furnishing them for the crude-oil mills. The crude oil, after being subjected to the treatment above mentioned, is known as "summer yellow." It sells for 26 to 28½ cents a gallon, while the crude oil is sold for 20 cents.

A prime summer yellow oil is also called butter oil, and is largely used in the manufacture of oleomargarine, butterine, etc. When a selected yellow oil is subjected to cold pressure, it becomes salad oil, used for salads and in cooking. Summer white oil is obtained from summer yellow by treating it with fullers' earth, or some other bleaching powder, and is used in the manufacture of compound lard and for like purposes. Winter white oil is the same as summer white, except that it has been cold pressed. It is used for burning in miners' lamps and in the manufacture of various medicinal compounds. Ordinary summer yellow is largely used in manufacturing, such as tempering steel, making of bolts and nuts, etc. As an illuminating oil it ranks next to sperm, but its principal use is as a food oil. Experts testified before the Tariff Commission in 1881 that 90 per cent of the oil sold as olive oil in the United States was really cotton seed oil. The Italian Government enacted a high-tariff regulation against the importation of cotton-seed oil into that country in competition with oils made there. Similar regulations have been made in Germany against refined cotton-seed oil, which in the form of butterine was being substituted for the butter of the German dairies.

The stearin left on the cloths in the filter press when the oil is refined is used for making butter and lard surrogates and candles.

As a food cotton-seed oil was first used as an adulterant to soften and temper lard intended for use in cold climates. Later on the fluidity of

the oil itself was corrected by mixing it with beef fat. This mixture was put on the market under the name of compound or refined lard. It was so kindly received by the public that before long all disguise was dropped and it was sold on its merits in competition with lard. The growing importance of this food stuff as an article of commerce is indicated by the fact that while the exportation of lard increased only 37 per cent between 1884 and 1893, that of cotton-seed oil and its compounds increased 162 per cent. (See p. 102).

PRESENT CONDITION AND OUTLOOK OF THE COTTON-OIL INDUSTRY.

It is not easy to form a well-defined idea of the progress, proportions, and prospects of an industry so new and in a stage of such rapid development as is the cotton-seed oil industry. Great improvements have been made in the machinery and its arrangement. It has also become cheaper as well as better. An outfit that ten years ago cost \$1,000 for each ton of seed it could crush in a day can be bought now for half that sum. The quantity of oil obtained from a ton of seed has been increased from 30 and 35 gallons to 40 and 44 gallons, which is a considerable advance toward the possible maximum yield of 53 gallons. The total cost of production ranged formerly from \$5.05 to \$6.49 for every ton of seed crushed; now it is done for \$2 to \$3 a ton, and occasionally for less. The cost of insurance, which was at one time 6 to 9½ per cent, is now only 1½ to 6 per cent, on account of the great security of loss from fires that has been effected. While the wages of labor have not been much reduced, its cost has, by the increase in the number of experienced workers and by the smaller number required on account of the labor-saving devices introduced. The labor chiefly employed is negro field labor, whose daily wage is from 40 to 50 cents. As, however, the pressman, cook, and linter-room man are select hands of some experience, the average wages run from 60 to 70 cents a day. A very small mill, without many of the labor-saving appliances of the larger ones, crushed 55 tons with 756 hours' labor, or something less than 14 hours to the ton. Putting the wages at 6 cents an hour for 12 hours' work, or 72 cents per day, this makes the labor cost of crushing a ton 84 cents. In point of fact, the cost in well appointed and managed mills runs from 75 to 95 cents per ton. Ten years ago the labor cost varied from \$1.84 to \$2.04 per ton of seed crushed. This does not include the salaries for superintendence and management. Formerly these were from 45 cents to \$1 a ton, but are now only 25 to 30 cents. The largest item, however, of cost—the cost of seed—can not be said to have fallen. While the price is variable, it is fully as high, and sometimes very much higher, than it was formerly. In the West, where they are cheapest, they were sold in 1880 for \$4 a ton; now they hardly ever bring less than \$6, and often more. In the East they sold, delivered at the mill, for \$14 per ton (21 cents per bushel). In recent years they have been as high as \$20 per ton (30 cents per bushel), and the price for this year of depression has been \$10 per ton (15 cents per bushel).

Relatively to the total cost of production, they are higher now, forming about 85 per cent of that cost, while formerly they were barely 70 per cent. This, of course, is the usual thing in all manufacturing industries. To obtain seed has been one of the greatest difficulties the oil industry has had to contend with from the very beginning. When Aldige, of New Orleans, was doing the first pioneer work in this direction, he could only collect 1,764 tons of seed after having an agent traveling for that purpose for eighteen months in the Mississippi Valley.

COST AND PROFIT OF THE COTTON-OIL INDUSTRY.

The profits of the oil industry depend naturally on the cost of the seed, the expense of working them, and the price of the products. The cost of the seed varies with the season. In seasons when oil-mill products are high they are high, and vice versa. They also vary greatly with the locality. In the West, as already stated, seed are about \$6 a ton, but these seed yield less oil than the higher-priced eastern seed, perhaps 25 per cent less, due, it is said, to the dryness of the climate, which prevents the full ripening of the kernel of the seed. The oil, however, due doubtless to this same dryness, which prevents the seed from spoiling, is of excellent quality. In the East the seed cost the mills \$8 to \$11. The following table shows the prices of cotton, cotton-seed oil, and lard in the New York market for a series of years, and also the prices of cotton-seed meal and hulls at the oil mills on the Atlantic Slope, as well as of corn:

Prices of cotton seed and other products, 1888-1894.

	1888.	1889.	1890.	1891.	1892.	1893.	1894.
Cotton, per pound.....cents..	10.3	10.65	11.07	8.6	7.71	8.24	7.67
Oil, per gallon.....do.....	39.5	38.25	29.25	28.75	29	39.35	27.75
Lard, per pound.....do.....	8.72	6.88	6.83	6.59	7.69	10.34	7.75
Cotton-seed meal, per ton.....dollars..	10	18.2	19.43	18.56	19.16	18.28	16.21
Corn, per bushel.....cents..	57.30	43	48.5	70.4	54	49.9	50.9
Cotton-seed hulls, per ton.....dollars..	.....	.....	2.46	2.65	2.15	1.59	2.25

It will be noticed that the fluctuations in lard have been greater than in oil, and greater for corn than for cotton-seed meal. The prices of hulls in the West where cattle are fattened for market are greater than those here stated, and at many of the mills in Texas the entire output of hulls is engaged beforehand by the cattlemen at \$4 a ton at the mills, and late in the season they sold at the eastern mills at \$5.50 per ton. The cost of working a ton of seed is approximately as follows: For seed, \$10.50; labor, 90 cents; salaries, 26 cents; repairs and supplies, \$1.20; taxes, 13 cents; total, \$12.99.

The value of products would be, 40 gallons of oil, at 20 cents per gallon, f. o. b., \$8; 700 pounds meal, at \$16.20 per ton, \$5.67; 25 pounds linters, at 2 cents per pound, 50 cents; 800 pounds hulls, at \$2 per ton,¹ 90 cents; total, \$15.07.

¹Since the use of hulls as cattle food has become so extensive they sell at from \$2.50 to \$4. (See p. 386.)

This would leave a net profit of \$2.08 per ton. For a 20-ton mill crushing in 100 days' run 2,000 tons of seed, this would amount to \$4,160, or a dividend of 10 per cent, on over \$40,000. The cost of such a mill would be: Machinery complete of the latest and best pattern, delivered at railroad station, \$10,000; buildings and placing machinery, \$4,000; power, \$2,000; in all, \$16,000. This statement may seem too favorable, but it is not overestimated. It is true that a number of mills have gone into bankruptcy—they were badly constructed or badly managed. Against this it would not be difficult to name mills that have declared dividends of 30 and even of 60 per cent, earned in one year's operations. It may be safely said that they are, as a rule, as prosperous as their rapid increase in numbers would indicate.

Although a large oil mill in Rhode Island was among the earliest to be established, the industry is now confined exclusively to the cotton States. Foreign seed are imported for manufacture in some European countries—France, Italy, and notably England, where 300,000 tons of seed brought from Egypt were crushed in 1887. In this country the cost of transportation has brought the mills to the seed. In the absence of reliable data, the following table, compiled from the best informed sources, is given to show the number of oil mills in each State, their average daily capacity, the total number of tons crushed during the season of 1894-95, the number of tons of seed produced in each State, and the percentage of that product worked by the mills.

Statistics of the cotton-seed oil industry, 1894-95.

State.	Num- ber of mills.	Average daily amount of seed crushed per mill.	Amount of seed produced.	Total amount of seed crushed.	Percent- age of seed produced that were crushed.
		<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	
Florida.....	2	15	24, 000	30, 000	125
Tennessee.....	18	62	143, 000	111, 600	77
Texas.....	90	63	1, 536, 500	557, 000	35
Arkansas.....	13	76	354, 000	100, 000	28
Louisiana.....	13	77	364, 000	100, 000	27
Mississippi.....	23	66	583, 500	155, 800	26
Georgia.....	35	43	591, 000	150, 000	25
South Carolina.....	25	31	409, 000	90, 000	22
North Carolina.....	14	35	247, 000	50, 000	20
Alabama.....	18	44	427, 000	80, 000	19
Other States.....			62, 500		
Total and average.....	251	56	4, 741, 500	1, 424, 400	30

The cotton crop of Florida is small, largely of cotton with downless seed, and here oil mills must draw a portion of their supply of material from beyond the borders of the State. It will be observed that the western mills have an average daily capacity to crush 62 to 77 tons, while the eastern mills work from 21 to 44 tons daily. The former also crush from 26 to 77 per cent of the amount of seed they produce, while the latter crush on an average 20 to 25 per cent of the seed grown within their boundaries.

The oil companies with large capital, who developed the industry,

were naturally attracted by the abundance and cheapness of seed in the West, and occupied this field with big mills. It was not until competition among themselves began to weaken them that the smaller mills, first in the Carolinas and Georgia and later in the West itself, got a solid foothold.

In the second stage of the development of the industry it becomes more and more apparent that small mills, purchasing their material directly from producers in their locality, free from the cost and charges of freight and agents, and disposing of the bulk of their products to consumers in their immediate neighborhood, can be run most economically and securely. It is in this aspect of the business that it offers a new future to southern agriculture as broad, as full of promise, and as far reaching as that created by the invention of the cotton gin itself.

The 800 pounds of hulls and the 700 pounds of meal (often counted at 900 pounds and 750 pounds) in every ton of seed responds to an urgent want where the seed is grown, not merely or even chiefly as a fertilizer to sustain the productiveness of the soil, but for the allied and more important purposes of stock feeding. Probably much of the oil might, with much saving and advantage, be substituted for the bacon and lard brought from a distance and consumed in the vicinity of the oil mills. It is half the price of olive oil, used exclusively for cooking in preference to anything else in many countries, and at the present prices it is cheaper than lard or bacon has ever been and probably will ever be. Of course it has to contend with gastronomic prejudices, but a closer acquaintance will dispel these. Such an acquaintanceship is to be observed among the laborers employed in the mills. They no longer bring meat for their dinners, but put their bread under the press where the sweet, warm, fresh oil is trickling out and eat it with a relish, finding it healthful and nutritious.

FERTILIZING VALUE OF THE SEED AND ITS PRODUCTS.

It is of great importance that the cotton growers should form a definite estimate of the value of this commodity to them in its raw and in its manufactured state. In the early days of cotton planting, when the gins began to furnish seed in quantity, they were thrown out carelessly upon the ground (as indeed is often done even now) and the hogs ate them and died (as they still do). To prevent this, the seed were inclosed in pens, but the small pigs made their way in between the rails and fed on the seed. They also died. As a last resort, to be rid of the nuisance once for all, the seed were dumped into a salt-water creek. Then, when the tide was low, they generated a miasmatic odor so offensive as to create a strong feeling against the future culture of the crop.

Cotton seed figures among the articles of export from the United States to Europe. In 1888, stimulated by the offer of \$35 a ton for seed in London, parties in Savannah collected a quantity and shipped

them. It was found when the cost, freight, commissions on selling, and other charges were counted up there remained a net surplus of \$1.14 a ton, allowing nothing for the management of the enterprise.

Before the oil mills were established, the highest valuation placed by cotton growers on the seed was 12½ cents per bushel, or \$8.29 a ton. Very little was ever sold. While a few cotton seed were boiled with other stuff and fed to milch cows, the butter made was not much esteemed, and the principal use made of the seed was for manure. Sometimes the seed were composted with stable manure, muck, and woods mold; but the most common practice, and that approved by the experience of the best farmers, was to apply the green seed in the drill, or in the hill, to cotton and corn. To do this it was necessary to put the seed out in February, for if this were done later they were likely in a warm spell to sprout. From 12 to 20 bushels were put to the acre. In larger quantities it was thought they ceased to be a benefit, and might even be a positive injury. The oil contained in the seed appears to be deleterious to plant life. Spots covered for any length of time by large piles of seed remain bare afterwards, as if they had been poisoned. Put on summer crops, in considerable quantity, it injures the stand. Piles of hulls also render the soil on which they have rested barren for a considerable time, and as almost any other covering adds to the fertility of the soil this must be attributed to some special property of the hulls, probably to the oil remaining in them.

The seed are perishable, bulky, and costly to store and to handle, and their use as fertilizer has been largely abandoned, especially in the vicinity of oil mills where the more effective cotton-seed meal can be obtained.¹

The mills now offer an exchange for the seed, which is a great deal more profitable to the cotton grower than using the seed. They give him 1 ton of meal for 2 tons of seed, paying the freight both ways. It is estimated that by this exchange there is a clear gain, transportation to and from the railroad not counted, of over \$5 for the farmer.

The gain is, in fact, much greater. The oil injurious to plants has in large measure been removed. A very perishable article, and one difficult to store and handle, is exchanged for one much more durable and cheaply handled. The effect of the meal is more lasting than that of the seed. Its mechanical condition is all that can be desired; its particles, having been subjected to great pressure, swell to three times their size when placed in the damp earth, and the farmer is often surprised to notice the large roll of dark material into which the thin yellow thread of meal has been transmuted in the soil. It is now recognized as one of the cheapest sources of nitrogen, the most costly and valuable ingredient of fertilizers. It did not obtain this recognition, however, without overcoming considerable prejudice. The State inspector of fertilizers for

¹ For composition with reference to fertilizing constituents of these products, see article on chemistry of cotton, p. 93.

Georgia, in 1876, refused to certify to a fertilizer as standard because it contained cotton-seed meal. Now it is generally used by all manufacturers of fertilizers.

FEEDING VALUE OF COTTON SEED AND ITS PRODUCTS.¹

But cotton-seed meal has a much more important use than that of a fertilizer. It stands among the feeding stuffs richest in protein, the most valuable and costly ingredient of all foods. In the average of the valuations of feeding stuffs made by the Connecticut, the New York, and the Indiana experiment stations, it is found that the value of cotton-seed meal exceeds that of corn meal by 62 per cent, and that of wheat by 67 per cent. According to the analysis of each, the feeding value of cotton-seed meal exceeds that of raw cotton seed by only 26 per cent. Practically, however, raw cotton seed has never been fed successfully to animals on any large scale. The lint on the seed and the dust they contain are injurious, it is not easy to mix them thoroughly with other forage, and so rich a food eaten in excess might easily prove deleterious. These objections are in a large degree removed by roasting them or boiling them with pumpkins, turnips, or other coarse foods. Such practice is more or less complicated and costly, and has not come into very general use. The comparison of the variable and complex natural product with the simple and uniform manufactured article is hardly more apposite than comparing an extract of the whole ox—hide, hoof, and horns—with a tenderloin steak.

Fattening cattle on cotton-seed meal and hulls.—The feeding and fattening of beef cattle on cotton-seed meal and cotton-seed hulls have been extensively carried on for a number of years. In the season of 1893-94 it is said that 13,000 car loads of beeves, fattened exclusively on this food, passed through Texarkana alone, going to the slaughterhouses of the Northwest. The business was chiefly carried on in the Gulf States at first, but it is gaining ground rapidly on the Atlantic Slope. Considerable shipments of meal and hull fattened cattle are being made from the Carolinas to Norfolk and other points north. When the mills commence to furnish hulls and meal the stockmen buy cattle and bring them to some suitable locality where there is an abundance of drinking water in close proximity to the oil mill. A yard is rented and fenced with barbed wire. These droves vary in number from 500 to 5,000 in one inclosure, being herded 50 head or upward to the acre. Shelters are no longer used. Troughs of unplanned boards, supported a foot or more above the ground, 8 feet long, 4 feet wide, and 18 inches deep, are scattered about in these open yards in numbers sufficient to prevent the cattle from crowding. The hulls are unloaded into the troughs from wagons bringing them directly from the mill, and cotton-seed meal is mixed with them, it being intended to give a ration of 3 pounds of it to the animal at the start, gradually increasing the

¹ See, also, article on the feeding value of cotton-seed products, p. 385.

amount until 8, 9, and even 10 pounds is fed at the close of 100 days, which is the average period in which they are fully fattened. Barrels of salt are left open in the inclosures and the cattle induced to drink all the water they will, and this is thought important on account of the stimulating and heating character of the food. As a rule the cattle take to this food with much relish. Sometimes they require a little coaxing to induce them to do so, and bran or other food to which they are accustomed is mixed with it, or it is sprinkled with molasses diluted with water. None refuse it finally. Little or no attention is paid to the manure. It is allowed to disappear without being utilized in these stock yards; sometimes it is given away as a nuisance to whoever will remove it, and occasionally it is sold at 20 to 50 cents a 2-horse wagon-load, chiefly to truck farmers and gardeners in the neighborhood of towns. A profit of \$5 to \$6 a head is considered fair pay for managing this business. Sometimes much more is realized, but in bad seasons, with inclement winters, high-priced cattle, and a poor market for meat, the gain is less, and in some instances a loss is incurred.

When it is considered that a conservative estimate places the value of the fertilizing elements in the feed that may be recovered in the manure at 80 per cent, the great wastefulness of the present practice is obvious.

The results obtained by feeding hulls and meal at the various agricultural experiment stations throughout the country have been most favorable. It is estimated that the hulls and meal when fed to cattle are capable of producing a gain in live weight worth \$30,000,000 at a cost of \$22,000,000. But a more important profit from this disposition of them remains to be mentioned. This is the manurial values which may be recovered from them after they have subserved the purposes of feeding. This can only be estimated from the value of the fertilizing ingredients they contain. As has been said, this varies according as it is viewed from two quite different points—that of their cost to the wholesale dealer in fertilizers and of their cost to the farmer. Taking the lowest statement of the amount of these ingredients that may be recovered (1,280,000 tons of hulls and 1,120,000 tons of meal), say 80 per cent, the calculation stands as follows:

Value of manure from animals fed cotton-seed hulls and meal.

	Pounds per ton.	Total.	Cost to wholesale dealer.		Cost to farmer.	
			Per pound.	Total.	Per pound.	Total.
Hulls:		<i>Pounds.</i>	<i>Cents.</i>		<i>Cents.</i>	
Nitrogen.....	15	19,200,000	12.16	\$2,334,720	24.17	\$4,640,640
Phosphoric acid	4	5,120,000	3.04	155,648	6.14	314,368
Potash.....	22	28,160,000	3.04	856,064	3.04	856,064
Meal:						
Nitrogen.....	141.6	158,592,000	12.16	19,284,797	24.17	38,331,686
Phosphoric acid	56	62,720,000	3.04	1,906,688	6.14	3,851,008
Potash.....	36	40,320,000	3.04	1,225,728	3.04	1,225,728
Total				25,763,645		49,219,494

That is to say, the seed of the cotton crop, once thought a nuisance, after yielding an income to the farmer, paying the wages of the hands employed in the oil mills, the salaries of the officers, keeping the property in good repair, and paying a dividend on the capital invested out of the oil and lint produced, after fattening a million and a third head of cattle for the market and furnishing the chief support of over 3,000,000 more for an entire year, may yield a value equal by one count to 65 per cent of all the commercial fertilizers sold in the United States in 1890, and by another count, based upon the actual cash cost to the farmer, a value equal to over \$11,000,000 more than the cost of the commercial fertilizers used on the 300,000,000 acres cultivated in the whole country. The potential value of the 4,000,000 tons of seed produced last year may be fairly stated in this way: 160,000,000 gallons oil, at 20 cents a gallon, \$32,000,000; 100,000,000 pounds of lint, at 2 cents, \$2,000,000; 1,600,000 tons of hulls and 1,400,000 tons of meal, which fed on the farm to cattle should produce in flesh and fat \$30,000,000 and in manure \$49,000,000. The total amounts to \$113,000,000, or very nearly half the value of the lint cotton of the last large crop. Results of practical experience and of scientific experiments can be cited which tend to corroborate this estimate.

It is being gradually found out that cotton-seed meal and hulls can be fed with advantage to other stock besides cattle and sheep. Instances are reported in which it has been successfully fed to horses and mules.

It has been stated that cotton seed in any form was injurious, and often fatal, to hogs. This is undoubtedly true as regards raw cotton seed. It would be of importance to determine what part of the seed—the lint, the hull, or the meal¹—was injurious to hogs, and the manner in which it acted. Mixed with other feed and cooked, hogs have been raised and fattened on it. It is reported to be beneficial to young poultry when mixed with other foods.

CONCLUSIONS.

(1) The tendency is toward the enlargement of ginneries. They are more economical and turn out a product of better quality.

(2) Oil mills of smaller size, on the contrary, are on the increase, and they are doing more of a local business. This saves in the cost of transporting and storing the bulky material to be manufactured, and stimulates a local demand for the products, which are of great importance to agriculture.

(3) The products of the small local mills are equal or superior to those of very large mills. They can select the seed more carefully, and they are not subject to the same amount of damage from heating during transportation and storage as when brought in great bulk from distant points.

¹ Recent French investigations show that the injurious effect of cotton seed is due to a poisonous principle peculiar to the kernel. (C. Cornevin, *Ann. Agron.*, 22 (1896), No. 8, p. 353.)

(4) The local mill should be of sufficient capacity to crush the seed as they arrive, and experience seems to show that a mill of 20 tons capacity can be worked as cheaply as a smaller one.

(5) The cost of the seed being the heaviest item in their manufacture, it is important to work them up as rapidly as possible to save money on interest and insurance.

(6) To ship seed to distant mills and purchase commercial fertilizers to replace them inflicts ruinous loss on the farmer, though it will profit to exchange them for meal or for meal and hulls.

(7) That the products of the seed when separated in the manufacture of oil are far more available and valuable as food for man or beast or as a fertilizer than they are in the lump in raw cotton seed.

(8) Much mystery has surrounded the operations of an oil mill in the past. This is passing away. Men who never saw an oil mill until they took charge of one have done so successfully and earned large dividends. The machinery presents no difficulties greater than that used in a ginhouse. Experts are required for refining, and the cook should have some experience. Laborers good about a ginhouse, under intelligent superintendence, are competent to work an oil mill.

(9) The business, once overshadowed by the oil trust and the large companies, is now open to all who wish to engage in it. With only a little over a third of the seed produced brought to the mills, it is found that competition among themselves matters less than the education of the farmers to an appreciation of the advantages to themselves of having their seed milled. Every new mill diffuses this knowledge, and opens a new territory of supply which accrues to the advantage of all engaged in the business.

(10) Rapidly as the oil mills are increasing, there seems little danger of overproduction. Its products are by far the cheapest of all commodities used for similar purposes, and may be substituted over a wide field for costlier articles of prime necessity. The material on which it operates is limited by the production of cotton in localities where enough is grown for mill purposes. Every new mill opens a new market. Every gallon of oil and every ton of hulls and meal that could be extracted from the largest crop would not suffice to supply the wants of the population of the cotton States and of the soil they cultivate, much less to overstock the markets of the world.

LINT.

MARKETING.

After the cotton is baled, the next step is to put it upon the market with the least delay practicable. Formerly the cotton planters, either themselves or through their factors, shipped their crops directly to the principal markets of this country or Europe. Now much the largest part of the crop goes at once into the hands of cotton factors or merchants who have made advances of cash or supplies to the farmers.

The usual amount of advances is intended to be about \$10 a bale at the highest legal rate of interest. The exigencies of the case generally cause them to exceed this, and the persistent decline in the price of the staple has made collections somewhat more difficult, and the business of making advances is by no means as it once was. The charge for selling and storage varies, but \$1 a bale for selling and 50 cents for storage for the first month and half that amount for each subsequent month may be considered a fair average. Insurance is to be counted also, so that it appears from the examination of some account sales that all the charges for selling sum up on an average to \$1.93 per bale, or to about 7 per cent on the net value of the crop to the farmer, or half a cent per pound of lint. With the increasing number of cotton factories in the South a larger amount of cotton is being sold directly to the mills. If it could be grown without the advances, these charges might all be saved. But the party making advances stipulates that such a number of bales be brought to them for storage and sale, and in case the specified number is not delivered a forfeit of \$1.50 for each bale short of the number is to be paid. The transactions of the farmer with the factory are very satisfactory. The morning paper informs both parties of the price of cotton the world over. The farmer is the better for saving the charges of the factor, and the mill saves agents' charges for buying, drayage, and freight, so that they agree easily with one another. Cotton brokers at the chief milling points, and even the spinners themselves in Europe and America, receive daily offers from peripatetic cotton buyers at numerous points in the interior to furnish cotton on through bills of lading at 10 to 15 points (50 to 75 cents a bale) above cost, insurance, and freight. The farmer brings his cotton to the town where some merchant or banker has advanced to him, several buyers bid on it, and the purchaser settles at the banker's or the merchant's, discharging the farmer's debt and giving him the residue. The cotton is put on the railroad platform to be shipped to the nearest compress and start on its journeyings. A large part of the business is transacted by the great exporting companies, many of them large concerns with the command of much capital, whose business it is to move most of the world's crops from producer to consumer. They are satisfied to clear an annual net profit of 6 per cent on the immense capital employed, and in doing this it is to their interest to cheapen the intermediate costs and bring the producer and consumer close together. As an evidence of the reduction made in these costs, it will be noticed that the transaction of these transfers by the large cities has been a great source of profit to them, and consequently of cost to the other parties, and of late years the annual sales of spot cotton in these cities has greatly decreased. This decline has been between 1876 and 1894, in New Orleans, from 31½ per cent of the crop to 12½ per cent; in Memphis, from 9¾ per cent to 4¼; in Savannah, from 5½ per cent to 2¼; in Charleston, from 7 per cent to 2¾. More direct and cheaper methods have skipped over these intermediary markets.

COST OF TRANSPORTATION.

The cost of transportation varies with each locality and the rates of freight, which are always fluctuating. Competitive lines, water transportation, the facility of arranging through freights, each brings its quota to complicate the problem. Distance is by no means a determining factor. It has sometimes cost less to ship cotton from the interior to Liverpool than to the New England mills. Changes are constantly occurring. The new Manchester Canal delivers cotton to the mills 30 cents a bale cheaper on the average than it is delivered ex-ship from Liverpool. Notwithstanding the general cheapening of transportation that has taken place, the percentage of this cost upon the total cost since the decline in the price of cotton is greater than when the staple sold high. It imposes an additional burden on importers and operates with other factors to render the manufacture of the raw material where it is grown more remunerative than it can be at distant points, and this will probably continue to be the case unless some unforeseen cause raises the price of cotton. It may be thought that as the product will finally have to be distributed the cost of transportation will attach as much to the manufactured article as to the raw material. This is a mistake, however. The transportation of cotton costs more than the transportation of goods. Where the first is charged 47 cents per hundred-weight, the latter goes through for 30 cents per hundredweight. Some idea of the charges and cost of transporting cotton will be conveyed by the following statement, giving these data regarding its shipment to Liverpool, where more of the crop has been always shipped than elsewhere:

Cost of shipping a 500-pound bale of cotton from the Atlantic Slope of the cotton States to Liverpool.

Items of cost.	Price per pound, 5 cents; first cost of 500-pound bale, \$25.	Price per pound, 8 cents; first cost of 500-pound bale, \$40.	Price per pound, 11 cents; first cost of 500-pound bale, \$55.
Grading.....per bale..	\$0. 15	\$0. 15	\$0. 15
Weighing.....do.....	.07½	.07½	.07½
Drayage.....do.....	. 10	. 10	. 10
Purchasing.....do.....	.50	.50	.50
Compressing and freight to port.....do.....	1. 40	1. 40	1. 40
Port to Liverpool.....do.....	2. 00	2. 00	2. 00
Liverpool dock dues, portorage, customs, insurance, forwarding, cartage to railroad, cartage to mill.....per bale..	.92	.92	.92
Total per bale.....	5. 14½	5. 14½	5. 14½
6 per cent tare.....	1. 50	2. 40	3. 30
Total cost per bale.....	6. 64½	7. 54½	8. 44½
Percentage of cost of transportation on total cost.....	24	18	15

With the improvements in machinery and increasing skill in its management, manufactured products have a tendency to become cheaper much more rapidly than the raw material out of which they are made. The production of the material depends on natural conditions beyond

human control; the manufactured goods are the result of human effort. In 1779 the value of the raw cotton in yarn was as 1 to 8; in 1860 it was as $6\frac{7}{8}$ to $11\frac{1}{2}$; in 1887 it was as $6\frac{1}{8}$ to $9\frac{1}{8}$. Therefore every burden put on the raw material, such as the above increase in the percentage cost of transportation to total cost, must obstruct manufactures. That it has already done so will be seen by the changes which have taken place in the consumption of cotton by various countries in a series of years, as shown in the following table:

Percentages of the cotton crop consumed in each country, 1859-1893.

Place of consumption.	1859.	1869.	1879.	1889.	1893.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Great Britain	55	48	36	40	35
Europe (Continental)	16	19	25	28	35
Other countries	6	3	3	.....	.....
Northern United States	19.4	27	32	24	20
Southern United States	3.6	3	4	8	10
Total	100	100	100	100	100

DISTRIBUTION.

Manufacturing is evidently becoming less the monopoly of any one nation, and it is equally plain that it tends more and more toward the sources of supply. The last observation is supported by what is taking place in India, next in importance to the Southern States as a cotton-producing country. The manufacture has increased there 283 per cent since 1880, and her cotton goods are supplanting those of Great Britain in China and the East. The rapid progress made recently in this direction in the cotton States leads the growers of the staple to hope that it will continue to grow, and that savings secured in the transportation and handling of cotton would open up a market not only for this crop but for all other crops necessary for the support of a large manufacturing population.

THE FEEDING VALUE OF COTTON-SEED PRODUCTS.

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The products of the cotton plant used as food for live stock are the seed, cotton-seed cake or meal prepared from the seed, and cotton-seed hulls.

Cotton as it is picked from the plant consists of seed and fiber or lint adhering to and covering the seed, in the proportion, by weight, of slightly less than one-third fiber and rather more than two-thirds seed. A crop of 9,000,000 bales in the United States would therefore yield about 4,500,000 tons of seed. The seed is composed of practically equal parts of seed coat or hull and kernel. From 1,000 pounds of the latter 250 to 300 pounds of oil is expressed, leaving 700 to 750 pounds of cake or meal to the ton of seed.¹

Prior to the era of cotton-seed oil mills raw and cooked cotton seed was fed largely to cattle and sheep, and to a limited extent to hogs. The larger portion of seed, however, was used as fertilizer, though in some of the richer cotton States the seed was sometimes thrown into rivers, buried, burned, or otherwise disposed of in the easiest way possible.

Cotton-seed cake is of two kinds—that from the whole seed, or uncorticated cake, and decorticated cake, or cake from the kernels after the hulls have been separated. The ground cakes give the cotton seed meal of commerce. Formerly undecorticated cake was largely made and used, but there are now probably not more than two mills in the United States making it.²

Cotton-seed meal was fed in the United States earlier than 1860³ and in England previous to 1864.⁴ The Southern States did not feed much meal at first, and most of it went to the Eastern and Northeastern States and to England. Its popularity as a feed has, however, gradually grown until now it is universally esteemed and large quantities are annually used for feed and fertilizer.

At the oil mills the cotton seed is cut up and crushed, and the hulls or seed coats separated from the kernels by means of screens and shakers. The hulls are dry, tough, and tasteless, and are covered with short cotton fiber. They were at first considered worthless for feeding

¹ Tenth U. S. Census; D. A. Tompkins in *Manufacturers' Record*, 1894, p. 257.

² D. A. Tompkins, communicated in letter.

³ U. S. Dept. Agr. Rpt. 1864, p. 275.

⁴ Jour. Roy. Agl. Soc., 1864, pt. 1. p. 235.

purposes, and were a nuisance at the oil mills, where, until about 1880, they were burned as fuel and are still thus disposed of to a very limited extent. Ten out of 16 oil mills mentioned in the Tenth United States Census reported the sale of hulls for feed, and it is likely they were used as feed before this, probably as early as 1870 in individual cases. So popular have they become as a coarse fodder that the oil mills now readily sell the greater portion of their output at from \$2.50 to \$4 a ton.

COMPOSITION OF COTTON-SEED PRODUCTS.

Cotton seed, of course, varies with the soil, season, and climate; but its composition with reference to these conditions has been studied but little. Beyond the observation of cotton-seed oil mills that the seed in a wet season contains more oil of poorer quality than in a dry season, we know little of the change in its composition due to different causes. The composition of cotton-seed meal, of course, depends on the composition of the seed and the completeness of separation of hulls and kernels and expression of oil from the latter. With the improvement in oil-mill machinery the percentage of oil left in the cake has been much reduced, as is seen from the averages of analyses made in consecutive years. (See p. 133.)

It is believed that the average of the analyses made since 1888 represents more nearly the composition of the cotton-seed meal of to-day than any of the previous ones. Cotton-seed hulls from different mills and even from the same mill vary widely in composition, owing to the adherence of larger or smaller quantities of the finely broken kernels. The composition of the cotton plant after the cotton is picked indicates it to be a very good coarse food, but it is extremely hard and tough, and would have to be manipulated before animals would eat it.

DIGESTIBILITY OF COTTON PRODUCTS.

The coefficients of digestibility of cotton products are brought together in the following table:

Coefficients of digestibility of cotton-seed products.

Ration.	No. samples.	No. determinations.	Dry matter.	Protein.	Albuminoids.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
<i>Experiments with ruminants.</i>									
Whole raw cotton seed in ration with corn silage.	1	2	P. ct. 66.1	P. ct. 67.9	P. ct. 63.6	P. ct. 87.1	P. ct. 49.6	P. ct. 75.5	P. ct. 43.3
Whole roasted cotton seed in ration with corn silage	1	2	55.9	47	44.2	71.7	51.4	65.9	-----
Cotton seed cake	-----	-----	74	84.7	-----	87.6	83.7	-----	-----
Cotton-seed meal in ration with clover hay	1	2	81.1	88.7	-----	100	67.8	-----	-----
Do	1	4	73.3	87.8	87.1	89.7	61.5	46.4	31.5
Cotton-seed cake and meal, average	-----	-----	76.1	87.1	-----	92.4	71	15.5	-----
Undecorticated Egyptian cotton-seed meal and cake	2	4	53.4	74.8	-----	89.2	53.6	12.4	17.6
Cotton-seed hulls fed alone	2	5	42.4	5	-----	73.8	31.8	51.8	23
Do	2	4	39.8	6.8	-----	85.1	36.9	43.1	19.9
Cotton-seed hulls, average	4	9	41.2	5.8	-----	78.8	34.1	48	21.6

These data need no comment except as regards whole, raw, and roasted seed. The digestibility of these was determined on two portions of the same lot of seed, one portion being fed raw and the other after roasting. Comparison of the coefficients shows that 10 per cent less of the dry matter of roasted seed, 21 per cent less of the protein, 15 per cent less of the fat, and 9.5 per cent less of the fiber was digested than in the case of the raw seed, while 1.7 per cent more of the nitrogen-free extract was digested from the roasted than from the raw seed. Ladd's¹ experiments also show raw cotton-seed meal to be more digestible than either steamed or cooked meal. Siewert² compared the composition of cotton-seed hulls before feeding with that of hulls separated from the solid excrement of animals, and claims that they were indigestible and worthless.

DOES COTTON-SEED MEAL AFFECT THE DIGESTIBILITY OF CARBONACEOUS FOODS?

It is usually stated³ that highly nitrogenous foods like cotton-seed meal have no influence on the digestibility of coarse, carbonaceous foods in rations, and vice versa. The results of two series of experiments at the North Carolina Station in which cotton-seed hulls and corn silage were each fed in connection with cotton-seed meal in varying proportions indicate that the cotton-seed meal influenced the digestibility of each of these coarse feeding stuffs. The digestibility of the cotton-seed hulls and silage when fed alone and when fed in various proportions with cotton-seed meal is shown in the following table:

Digestibility of cotton-seed hulls and corn silage fed alone and with cotton-seed meal.

Ration.	Number of determinations.	Dry matter.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Nutritive ratio.	
							By actual digestion.	As calculated from single foods.
Cotton-seed hulls:		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>		
Fed alone <i>a</i>	4	39.8	6.8	85.1	36.9	43.1	-----	-----
With cotton-seed meal (7 parts of hulls to 1 of meal) <i>a</i>	1	40.6	-12.6	78.4	50.2	33.5	1:10.8	1: 6.93
With cotton-seed meal (6 parts of hulls to 1 of meal) <i>a</i>	2	41.1	-35.7	78	48	40.1	1: 9.71	1: 7.69
With cotton-seed meal (4 parts of hulls to 1 of meal) <i>a</i>	2	47.7	-36	78.9	57.1	45	1: 7.52	1: 5.62
With cotton-seed meal (3 parts of hulls to 1 of meal) <i>a</i>	1	48.5	-22.3	83	53.6	49.8	1: 5.89	1: 4.62
With cotton-seed meal (2 parts of hulls to 1 of meal) <i>b</i>	4	44.1	-43	72.4	48.2	48	1: 4.02	1: 3.28
With cotton-seed meal (1½ parts of hulls to 1 of meal) <i>c</i>	2	44.3	-50	79.7	53.5	45.7	1: 3.18	1: 2.71
Corn silage:								
Fed alone <i>d</i>	1	53.2	34.4	66	60.5	43.2	-----	-----
With cotton-seed meal (12 parts of silage to 1 of meal) <i>d</i>	2	60.1	19	79.3	68.9	57.5	1: 6.29	1: 5.57
With cotton-seed meal (8 parts of silage to 1 of meal) <i>d</i>	2	67.4	24.5	54.7	76.3	64.3	1: 4.98	1: 4.01

a North Carolina Sta. Buls. 97, 122.

b North Carolina Sta. Buls. 97 and 111.

c North Carolina Sta. Buls. 111.

d North Carolina Sta. Buls. 97, 123.

¹ Pott, Die Landwirtschaftlichen Futtermittel, p. 133.

² Landw. Vers. Stat., 30 (1884), p. 145.

³ Armsby, Manual of Cattle Feeding, p. 277.

The corn silage fed in the above trials was all from the same lot. From these figures it appears that the digestibility of the carbohydrates has been materially increased in the case of both coarse fodders by feeding cotton-seed meal, while there was in all cases a loss of protein which with the hull rations was much beyond what the hulls contained. The nutritive ratios of these rations as actually digested and as calculated from the digestion coefficients of the different feeding stuffs also show that these foods have affected the digestibility of each other, and indicate that in rations of this kind, at least, much wider nutritive ratios are fed than is generally supposed.

FEEDING COTTON-SEED PRODUCTS FOR BEEF PRODUCTION.

ENGLISH EXPERIMENTS.

Experiments have been made on bullocks at Woburn,¹ England, in which decorticated and undecorticated cotton-seed cake have been compared with each other, and decorticated cake has been compared with various grain rations. In compiling these the nutritive ratios of the rations have been calculated only in those cases in which the composition of all of the feeding stuffs used was given; and the digestible organic matter and the amounts necessary to produce 1 pound of gain have been calculated only where the composition of the more important foods was given. The total cost of each pound of gain and of the additional foods for 1 pound of gain are based on estimates of the experimenters.² The results of these experiments are summarized in the table below, followed by further details and deductions:

Feeding experiments for beef at Woburn, England, with cotton-seed cake combined with other feeding stuffs.

Daily ration per animal	Digestible organic matter in daily ration.	Nutritive ratio of ration.	Average daily gain in weight.	Digestible organic matter eaten per pound of gain.	Cost of concentrated food per pound of gain.	Total cost of food per pound of gain. ^a
1887-88. Coarse fodder: straw chaff, hay chaff, and roots, alike to all:						
Lot 1, 3 pounds decorticated cotton-seed cake, 3 pounds linseed cake, and 3 pounds maize meal.	<i>Pounds.</i> 14.63	1: 4.82	<i>Pounds.</i> 2.65	<i>Pounds.</i> 5.52	<i>Cents.</i> 5.29	.....
Lot 2, 3 pounds bean meal, 3 pounds oats, and 3 pounds barley	14.45	1: 6.56	2.35	6.14	6.40	.....
Lot 3, 3 pounds oats, 3 pounds "gritted" wheat, and 3 pounds barley	14.44	1: 8.53	2.15	6.71	6.46	.....
1889-90:						
Lot 1, 4.33 pounds decorticated cotton-seed cake, 4.34 pounds linseed cake, 13.73 pounds hay chaff, and 40.18 pounds roots	16.56	1: 4.67	3.12	5.30	.....	8.95
Lot 2, 2.12 pounds decorticated cotton-seed cake, 2.17 pounds linseed cake, 15.49 pounds hay chaff, and 44.27 pounds roots	14.97	1: 5.95	2.54	5.89	.....	8.73

^aWhere the composition of the foods used was not given, hay chaff was assumed to contain 78.5 percent of organic matter, ruta-bagas and mangel-wurzels 10.4 per cent, and wheat straw 80.8 per cent. Wheat was assumed to be as digestible as barley.

¹All the Woburn experiments were made under the auspices of the Royal Agricultural Society by Dr. Voelcker.

²This explanation applies to all other similarly presented experiments.

Feeding experiments for beef at Woburn, England, etc.—Continued.

Daily ration per animal.	Digestible organic matter in daily ration.	Nutritive ratio of ration.	Average daily gain in weight.	Digestible organic matter eaten per pound of gain.	Cost of concentrated food per pound of gain.	Total cost of food per pound of gain. <i>a</i>
1889-90:						
Lot 3, no grain, 17.03 pounds hay chaff, and 48.44 pounds roots	Pounds. 13.29	1:10.52	Pounds. 1.36	Pounds. 9.77	Cents. -----	Cents. 12.00
1888-89. Coarse fodder; hay chaff and roots, alike to all:						
Lot 1, 3.3 pounds decorticated cotton-seed cake, 2.88 pounds linseed cake, and 4 pounds barley	14.58	1: 4.21	2.21	6.59	7.60	-----
Lot 2, 3.3 pounds undecorticated cotton-seed cake, 2.88 pounds linseed cake, and 4 pounds barley	13.83	1: 5.15	1.97	7.02	8.38	-----
1890-91. Coarse fodder: hay chaff and roots, alike to all:						
Lot 1, 5.03 pounds decorticated cotton-seed cake, 3 pounds linseed cake, and 1 pound barley	17.17	-----	2.38	7.21	6.42	-----
Lot 2, 5.07 pounds undecorticated cotton-seed cake, 3 pounds linseed cake, and 1 pound barley	15.89	-----	1.84	8.63	7.34	-----
1878-79. Coarse fodder: roots and wheat chaff, alike to all:						
Lot 1, 7.69 pounds decorticated cotton-seed cake, 7.88 pounds maize meal	17.13	-----	2.32	7.39	10.43	-----
Lot 2, 13.92 pounds linseed meal	15.62	-----	2.29	6.81	12.63	-----
1880. Coarse fodder: hay chaff, wheat chaff, and roots, alike to all:						
Lot 1, 7.7 pounds decorticated cotton-seed cake, 7.7 pounds maize meal	16.24	-----	2.60	6.24	10.43	-----
Lot 2, 15.4 pounds linseed cake	15.17	-----	2.12	7.15	17.68	-----
1880-81. Coarse fodder: hay chaff and mangel-wurzel:						
Lot 1, 9.48 pounds decorticated cotton-seed cake, 9.48 pounds maize meal	19.70	-----	2.63	7.49	12.58	-----
Lot 2, 17.18 pounds linseed cake	17.68	-----	1.64	10.81	23.84	-----

a Where the composition of the foods used was not given, hay chaff was assumed to contain 78.5 per cent of organic matter, ruta-bagas and mangel-wurzels 10.4 per cent, and wheat straw 80.8 per cent. Wheat was assumed to be as digestible as barley.

The experiments of 1887-88¹ were made "with a view to seeing how far home-grown food could be utilized and how it would compare with cake." Twelve 3-year-old Hereford bullocks were fed during 112 days in three lots, one lot receiving cotton-seed cake, linseed cake, and maize meal, another lot bean meal, oats, and barley, and the third lot "gritted" wheat, oats, and barley. All three lots had the same kind and amount of coarse fodder. The first-mentioned lot was fed in box stalls, the second in the open yard, and the third under a shed; but no difference in the result is attributed to these different conditions. The rate and cost of gain show "clearly the superiority of the cake feeding; * * * the meat of the cake-fed beasts was pronounced by experts to be 'riper' than that of the bean-fed beasts," and the latter was superior to that of the wheat-fed lot.

In 1889-90² the experiments were to see "to what extent cake would replace hay in feeding bullocks." Fifteen 3-year-old Hereford bullocks were fed during three periods of 40, 41, and 29 days, making 110 days

¹ Jour. Roy. Agl. Soc. England, ser. 2, 24 (1888), pp. 481-486.

² Jour. Roy. Agl. Soc. England, ser. 2, 1 (1890), pp. 399-407.

in all. A ration of cotton-seed cake and linseed cake was fed to lot 1, one-half this amount to lot 2, and none to lot 3, the diminished quantity of oil cakes being made up for by an increasing ration of hay chaff and roots. The bullocks receiving the full quantity of oil cakes gained on an average 3.87, 3.05, and 2.20 pounds daily per head during the respective periods; those receiving the half ration of oil cakes gained 3.18, 2.56, and 1.63 pounds, and those having roots and hay only, 1.52, 2.06, and 0.12 pounds. The average gains for the whole period of 110 days are given in the table, together with their cost, which shows the single quantity of cake to have been the most economical meat producer, unless the manurial value of the rations is taken into consideration, in which case double quantity of oil cakes was the most economical, and far more so than roots and hay alone.

The object of the experiments in 1888, 1889, and 1890¹ was to investigate the comparative feeding values of decorticated and undecorticated cotton-seed cake when fed in like amounts. In 1888-89 eight 3-year-old Hereford bullocks were fed in two lots during three periods of 62, 36, and 47 days, respectively. The 4 bullocks receiving decorticated cotton-seed cake gained 2.76, 2.01, and 1.64 pounds per head daily during the respective periods, while the 4 on undecorticated cake gained 2.47, 1.65, and 1.56 pounds. During 1890-91 17 3-year-old Shorthorns were fed in three periods of 41 days each, the 8 on decorticated cake gaining 2.4, 2.48, and 2.28 pounds per head daily, and the 9 on undecorticated cake 1.33, 2.36, and 1.82 pounds. The foods other than the cakes in each of the two trials were practically the same, and any differences in results are attributed to the cakes. The gains for the whole periods and the cost are given in the table and are favorable in both cases to the decorticated cake. The experimenter considers "that for feeding purposes alone, omitting manurial value, decorticated cotton-seed cake is fully worth 50 shillings a ton more than undecorticated cotton-seed cake."

The experiments in 1878, 1879, 1880, and 1881² were to test the comparative value of a mixture of decorticated cotton-seed cake and maize meal against linseed cake as additional foods for fattening bullocks, the other foods (roots and hay) being alike. In the first trial 2 lots of 4 Herefords each were fed for 69 days, and in the second and third trials 2 lots of 3 bullocks each were fed for 63 days in each case. The gains and cost lead the experimenter to conclude that "in three successive years a mixture of equal parts of decorticated cotton-seed cake and maize meal has produced a larger increase in live weight, and at less cost than linseed cake."

Other feeding experiments³ with decorticated cotton-seed cake in

¹ Jour. Roy. Agl. Soc. England, ser. 3, 2 (1891), pp. 585-594.

² Jour. Roy. Agl. Soc. England, ser. 2, 16 (1880), p. 149, and 17 (1881), p. 654.

³ Jour. Roy. Agl. Soc. England, 2d ser., vols. 16-23, pp., 131, 112, 301, 209, 337, 348, 236, 284, 289.

addition to other foods have also been made with bullocks at Woburn in connection with studies on the production of manure. The results of these experiments are brought together in the following table:

Feeding experiments for beef at Woburn, England, with cotton-seed cake in combination with other feeding stuffs.

Daily ration per animal.	Dura- tion of period.	Num- ber of ani- mals.	Average weight of animals.	Digest- ible organic matter in daily ration.	Average daily gain in live weight.	Digest- ible organic matter eaten per pound of gain.
1879:						
First period, 4 pounds cotton-seed cake, 6.4 pounds maize meal, 8 pounds wheat chaff, (a)	<i>Days.</i>		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
and 48 pounds white turnips	35	4	1,086	14.19	1.03	13.80
Second period, same	35	4	1,121	14.19	2.02	7.02
1880:						
First period, same as in 1879, except mangel- wurzels in place of turnips	35	4	1,032	.....	1.41	.....
Second period, same	35	2	1,102	.....	1.41	.....
1881:						
First period, 5½ pounds cotton-seed cake, 8.53 pounds maize meal, 10½ pounds wheat chaff, and 64 pounds white turnips	35	3	1,343	.....	2.48	.....
Second period, same	35	3	1,358	.....	2.07	.....
1882:						
First period, 3½ pounds cotton-seed cake, 5½ pounds maize meal, 6½ pounds wheat chaff, and 40 pounds white turnips	21	4	1,080	11.03	3.39	3.25
Second period, same	21	4	1,064	11.03	2.67	4.14
1883:						
First period, 2.92 pounds cotton-seed cake, 4.67 pounds maize meal, 5.83 pounds wheat chaff, and 35 pounds white turnips	24	3	1,146	9.49	2.03	4.68
Second period, same	24	4	1,124	9.49	1.96	4.85
1884:						
First period, same as 1883	24	4	1,044	10.47	2.91	3.60
Second period, same	24	4	1,040	10.47	1.76	5.95
1883:						
First period, 7.56 pounds cotton-seed cake, 10.25 pounds wheat chaff, and 40.98 pounds mangel-wurzels	61	2	1,155	12.42	.72	17.42
Second period, 8.47 pounds maize meal, 10.6 pounds wheat chaff, and 42.35 pounds mangel-wurzels	59	2	1,214	13.79	1.38	9.99
Third period, 10.6 pounds wheat chaff and 42.35 pounds mangel-wurzels	59	1	1,059	7.68	.05	.....
1884:						
First period, 7.21 pounds cotton-seed cake, 9.77 pounds wheat chaff, and 39.06 pounds mangel-wurzels	64	2	1,119	11.97	1.63	7.37
Second period, 7.81 pounds maize meal, 9.77 pounds wheat chaff, and 39.06 pounds mangel-wurzels	64	2	1,100	12.86	1.78	7.22
Third period, 10.42 pounds wheat chaff and 41.67 pounds mangel-wurzels	60	4	1,031	7.55	— .33	.....
1885:						
First period, 3.18 pounds cotton-seed cake, 5.08 pounds maize meal, 6.36 pounds wheat chaff, and 38.18 pounds white turnips	22	3	1,033	11.51	1.37	8.42
Second period, same	22	4	1,034	11.51	1.25	9.21
1886:						
First period, 3½ pounds cotton-seed cake, 5½ pounds maize meal, 8 pounds wheat chaff, and 42.19 pounds ruta-bagas	21	4	1,110	13.20	3.50	3.77
Second period, same	21	4	1,107	13.20	3.11	4.25
Third period, same	21	4	1,105	13.20	3.10	4.26

a Wheat chaff in the above experiments was assumed to contain 80.8 per cent of organic matter, swedes and mangel-wurzels 10.8 per cent, and white turnips, where the composition is not given, 9.4 per cent.

b There were four animals in this experiment; one lost weight and one was too wild to weigh, and both are excluded.

c There were four animals in each of these experiments, but in every case one was sick for several days and lost weight, and was excluded in making up results.

In 1879, 1880, and 1881 the amounts of different kinds of feeding stuffs eaten were the same, i. e., 5 hundredweight of decorticated cotton-seed cake, 8 hundredweight of maize meal, 60 hundredweight of roots, and 10 hundredweight of wheat-straw chaff, the kind of roots or substitute for roots being different each year, as indicated in the table. During the experiments of 1882, the first series of 1883 and 1884, and those of 1885 the animals ate the same total amounts of foods, which were just one-half the amounts given in the experiments of the previous three years.

In 1886 each lot of animals ate $2\frac{1}{2}$ hundredweight of decorticated cotton-seed cake, 4 hundredweight of maize meal, 6 hundredweight of wheat-straw chaff, and 31.68 hundredweight of ruta-bagas. The bullocks were 3-year-old Herefords, and the first two lots were fed tied up in the feeding boxes, as in all the previous experiments, while the third lot was fed loose in an open yard. It is believed that no difference in the gains could be attributed to the different conditions of feeding. The first lots of bullocks in the second series of experiments in 1883 and 1884 each consumed 923 pounds of decorticated cotton cake, 1,250 pounds of wheat-straw chaff, and 5,000 pounds of mangel-wurzels; the second lots, 1,000 pounds of maize meal, 1,250 pounds of wheat-straw chaff, and 5,000 pounds of mangel-wurzels, respectively; the third lots, 1,250 pounds each of wheat-straw chaff and 5,000 pounds of mangel-wurzels. The gains in these experiments clearly show the value of the additional foods (cotton-seed cake and maize meal), the straw chaff and mangel-wurzels not proving sufficient to maintain the original body weight. The gains in these experiments, taken as a whole, are quite wide for the foods to have been the same.

AMERICAN EXPERIMENTS.

Gulley and Curtis,¹ at the Texas Station, in three years' experiments in fattening 160 Texas steers and 8 cows on cotton-seed products in different rations, in comparison with each other and with corn, obtained results in all cases indicating the superior feeding qualities of cotton-seed products over corn in rations with hay, silage, or hulls. Rations of cotton-seed hulls and cotton-seed meal,² or the former with silage added, were concluded to be best for long periods of fattening, eighty days and over, as they produced larger gains and more continuous growth and fattening than others. Rations of cotton seed, especially boiled, with silage, and of cotton seed, corn, and hay gave cheaper and more rapid gains for short periods (about thirty days), but they loaded the animals with fat so quickly that the rate of laying on flesh was greatly decreased, and the beef was not considered so good. Cotton-seed meal was considered better for feeding with silage or silage and hulls than cotton

¹Texas Sta. Buls. 6, 10, and 27.

²These rations were made up practically of 3 and 2.6 pounds of hulls to 1 of meal, the latter having a nutritive ratio of 1:3.68. (See exclusive cotton-seed hull and meal feeding.)

seed, as it was believed that cotton seed charged the animal with fat and stopped growth, while meal accelerated it. Cotton-seed meal produced greater gains at greater cost. Cotton-seed hulls at \$3 per ton gave better results than silage at \$2; raw and boiled cotton seed at \$7 made much cheaper but smaller gains than cotton-seed meal at \$20, and the hay and corn rations were the dearest ones fed.

From the third year's experiments at the Texas Station, Connell and Carson¹ conclude that boiled and roasted cotton seed are more palatable, less laxative, and produce more rapid gains than raw cotton seed, but that the latter makes the cheapest gains; and that roasting seed does not repay the expense.

An 8-year-old grade Shorthorn steer at the Alabama Station² made a better gain on cotton-seed meal and cotton-seed hulls than a 10-year-old steer on cotton-seed meal and hulls and mixed hay, and the latter a better gain than a 3 to 4 year-old steer on corn meal and cowpea-vine hay. Cotton-seed hulls were better relished by them than cowpea-vine hay.

Miller,³ at the Maryland Station, found corn-and-cob meal, cotton-seed meal, and wheat bran (15, 4, and 2 parts of each, respectively), which formed a "well-balanced ration" with coarse foods, to produce an average daily gain of 2.78 pounds against a gain of 1.70 pounds, at greater cost, on corn-and-cob meal, which formed a "poorly balanced ration" with the same coarse and carbonaceous foods. The beef from the well-balanced ration was more even and of better quality.

In four years' experiments at the Pennsylvania Station⁴ mixtures of corn meal and cotton-seed meal with coarse foods produced better and cheaper gains than corn meal alone with the same coarse foods, cotton-seed meal replacing more than its own weight of corn meal in the rations and reducing the amount of food required to produce a pound of gain.

The Arkansas Station⁵ found that cotton-seed hulls and meal⁶ (3.3 to 1) produced cheaper and more rapid gains than raw seed, hulls, and cowpea-vine hay; the latter cheaper but slower gains than cotton-seed meal with the same coarse foods, and each of these gave better results than raw seed and cowpea-vine hay. Cotton-seed meal produced faster gains in all cases than raw seed.

Nourse⁷ found that whole corn or corn meal in rations with silage and hay produced better and more economical gains than combinations of equal parts of corn or corn meal and cotton-seed meal, corn meal and wheat bran, or cotton-seed meal and wheat bran. The gains in weight

¹ Texas Sta. Bul. 27.

² Alabama Canebrake Sta. Bul. 8.

³ Maryland Sta. Bul. 22.

⁴ Pennsylvania Sta. Buls. 6, 10, and 12 (old ser.).

⁵ Arkansas Sta. Rpt. 1890, p. 134.

⁶ For this ration see exclusive cotton-seed hull and meal feeding.

⁷ Virginia Sta. Bul. 3.

cost from 9.2 cents per pound on the widest ratio to 27.2 cents on the narrowest. These gains cost far more than they sold for, but the increased quality of the whole animal more than compensated for it. Jordan,¹ at the Maine Station, compared equal weights of corn meal and cotton-seed meal in rations with other foods for young steers, and found the growth to be practically the same on the two rations. Rations of cotton-seed meal with other foods were fed to 1 and 2 year-old steers at the Massachusetts State Station² without very remunerative returns. Combinations of corn meal and cotton-seed meal were compared at the Pennsylvania Station³ with corn meal alone, in rations with the same coarse foods, with results favorable in one case to cotton-seed meal and in another to corn meal, but the results as a whole, especially when manurial values are considered, were favorable to cotton-seed meal. The Maine Station⁴ obtained cheaper growth on equal weights of corn meal and cotton-seed meal with oat straw than on the same amounts of corn meal with hay; and in another experiment⁵ cotton-seed meal substituted for a portion of the corn meal in moderate rations with hay or oat straw diminished the cost and amount of food required to produce a pound of gain.

The data upon which this discussion is based are summarized in the following tables:

I.—Results of feeding cotton-seed products for beef production.

Ration.	Duration of period of experiment.	Number of animals.	Average live weight of animals.	Total daily ration.	Average daily gain in live weight.	Cost of food per pound of gain.
TEXAS STATION EXPERIMENTS. (a)						
<i>Old cows.</i>						
4.74 pounds boiled cotton seed, 4.02 pounds cotton-seed meal, 11.93 pounds silage, 6 pounds corn fodder	<i>Days.</i> 48	8	<i>Pounds.</i> 788	<i>Pounds.</i> 26.69	<i>Pounds.</i> 2.67	<i>Cents.</i> 3.14
<i>3 to 4 year-old Texas steers.</i>						
5.97 pounds cotton-seed meal, 22.7 pounds silage, 3.07 pounds hay	83	6	781	31.74	2.05	4.47
9.19 pounds boiled cotton seed, 20.19 pounds silage, 2.30 pounds hay	83	6	863	31.68	2.08	2.85
7.15 pounds raw cotton seed, 18.80 pounds corn silage, 2.36 pounds hay	83	6	901	28.31	1.80	2.86
4.39 pounds cotton-seed meal, 20.76 pounds corn silage, 1.89 pounds hay, 8.63 pounds corn-and-cob meal	83	6	906	35.67	2.37	5
5.85 pounds cotton-seed meal, 12.95 pounds corn silage	80	6	810	30.15	2.20	3.93
8.09 pounds hay, 16.39 pounds ear corn	83	11	834	24.48	2	5.50
<i>10 Texas steers, and 3 grades in pens.</i>						
5.56 pounds cotton-seed meal, 13.31 pounds cotton-seed hulls, 20.52 pounds corn silage	81½	13	830	39.39	3.30	2.95
<i>a Texas Sta. Buls. 6, 10, and 27.</i>						

¹Maine Sta. Rpt. 1890, p. 71.

⁴Maine Sta. Rpt. 1886, p. 73.

²Massachusetts Sta. Rpt. 1892, p. 92.

⁵Maine Sta. Rpt. 1887, p. 89.

³Pennsylvania Sta. Rpt. 1886, p. 228.

I.—Results of feeding cotton-seed products for beef production—Continued.

Ration.	Duration of period of experiment.	Number of animals.	Average live weight of animals.	Total daily ration.	Average daily gain in live weight.	Cost of food per pound of gain.
TEXAS STATION EXPERIMENTS (a)—continued.						
4 to 6 year-old Texas steers in pens.						
5.45 pounds raw cotton seed, 11.68 pounds corn silage, 4.69 pounds hay, 6.15 pounds corn-and-cob meal.....	Days. 79	9	Pounds. 774	Pounds. 27.97	Pounds. 2.81	Cents. 2.67
4.33 pounds boiled cotton seed, 7.49 pounds hay, and 15.33 pounds corn-and-cob meal.....	79	3	753	27.15	2.95	3.86
2 to 3 year-old Texas steers in pens.						
4.78 pounds cotton-seed meal, 7.81 lbs cotton-seed hulls, 17.81 pounds corn silage.....	83½	12	625	15.45	2.21	3.29
6.68 pounds roasted cotton seed, 3.71 pounds hay, 5.06 pounds corn-and-cob meal.....	83½	12	619	16.37	2.26	3.23
7.89 pounds boiled cotton seed, 3.38 pounds hay, 5.10 pounds corn-and-cob meal.....	83½	12	633	30.40	2.28	3.41
5.50 pounds raw cotton seed, 4.26 pounds hay, 5.07 pounds corn-and-cob meal.....	83½	12	586	14.83	2.07	2.90
5.39 pounds hay and 13.02 pounds corn-and-cob meal.....	83½	12	604	18.41	1.89	4.68
2 and 3 year-old Shorthorn and Hereford grades fed in pens.						
4.07 pounds cotton-seed meal, 16.59 pounds cotton-seed hulls, 4.97 pounds corn-and-cob meal.....	90	4	885	25.63	2.29	4.09
5.91 pounds cotton-seed meal, 13.83 pounds cotton-seed hulls, 6.31 pounds hay.....	90	8	833	26.05	2.39	4.13
6.22 pounds cotton-seed meal, 19.62 pounds cotton-seed hulls, 0.57 pint molasses.....	90	7	909	26.41	2.72	3.89
7.97 pounds boiled cotton seed, 9.18 pounds corn silage, 3.11 pounds corn fodder, and 0.31 pound hay.....	90	6	874	20.57	1.79	2.55
3.59 pounds cotton-seed meal, 23.99 pounds corn silage, 4.22 pounds corn-and-cob meal.....	90	4	774	31.80	1.82	4.60
7.61 pounds boiled cotton seed, 22.42 pounds corn silage, 0.40 pound hay.....	90	6	838	30.43	1.82	2.70
5.64 pounds cotton-seed meal, 37.79 pounds corn silage, 0.32 pint molasses.....	90	4	831	43.75	2.22	4.47
PENNSYLVANIA STATION EXPERIMENTS. (b)						
Western steers.						
3.95 pounds cotton-seed meal, 6.27 pounds corn fodder, 9.85 pounds corn meal.....	97	2	1,214	20.07	1.94	12.50
6.15 pounds corn fodder, 15 pounds corn meal.....	97	2	1,214	21.15	1.35	17.77
4.12 pounds cotton-seed meal, 3.50 pounds corn fodder, 10.37 pounds corn meal.....	49	2	1,225	17.99	1.43	14.60
3.50 pounds corn fodder, 18 pounds corn meal.....	49	2	1,205	21.50	1.98	12.51
4.12 pounds cotton-seed meal, 8 pounds hay, 10.37 pounds corn meal.....	42	2	1,342	22.49	2.02	11.66
8 pounds hay, 18 pounds corn meal.....	42	2	1,327	26	2.26	12.08
Pennsylvania steers.						
4 pounds cotton-seed meal, 8.5 pounds corn fodder, 8 pounds corn meal.....	84	2	1,035	20.50	1.55	14.61
5 pounds corn fodder, 15.65 pounds corn meal.....	84	2	961	20.65	1.04	24.84
2 and 3 year old steers (2 of each).						
3 pounds cotton-seed meal, 3.88 pounds corn fodder, 6 pounds corn meal.....	28	4	955	12.88	1.74	6.20
2.12 pounds corn fodder, 12 pounds corn meal.....	28	4	989	14.12	1.78	6.20
3 pounds cotton-seed meal, 10 pounds hay, 6 pounds corn meal.....	28	4	1,020	19	2.05	7.20
9.77 pounds hay, 12 pounds corn meal.....	28	4	1,055	21.77	1.47	10.85

a Texas Sta. Buls. 6, 10, and 27.

b Pennsylvania Sta. Buls. 6, 10, and 12, old ser.

I.—Results of feeding cotton-seed products for beef production—Continued.

Ration.	Duration of period of experiment.	Number of animals.	Average live weight of animals.	Total daily ration.	Average daily gain in live weight.	Cost of food per pound of gain.
MARYLAND STATION EXPERIMENTS. (a)						
3-year-old grade Shorthorns.						
2.50 pounds cotton-seed meal, 12.20 pounds corn fodder, 9.36 pounds corn-and-cob meal and 0.50 pint molasses, 1.25 pounds corn meal, 9.33 pounds roots.....	Days. 90	4	Pounds. 1,113	Pounds. 35.14	Pounds. 2.78	Cents. 7.05
11.50 pounds corn fodder, 10.90 pounds corn-and-cob meal and 0.27 pint molasses, 9.33 pounds roots.....	90	4	1,062	32	1.70	8.59
ALABAMA STATION EXPERIMENTS. (b)						
10 to 12 year old work oxen.						
7.17 pounds raw cotton seed, 20.64 pounds hay with some cotton-seed hulls mixed with it.....	105	1	1,328	27.81	.22	54.29
3.71 pounds cotton-seed meal, 24.94 pounds hay with some cotton-seed hulls mixed with it.....	105	1	1,422	28.65	1.83	7.56
3 to 4 year old steers.						
21.45 pounds hay, 3.26 pounds corn meal.....	105	1	990	24.71	1.71	7.55
ARKANSAS STATION EXPERIMENTS. (c)						
2 to 2½ year old steers.						
3.40 pounds raw cotton seed, 14.48 pounds cowpea-vine hay.....	90	2	718	17.88	1.92	4.99
3.44 pounds raw cotton seed, 11.35 pounds cotton-seed hulls, 8.07 pounds cowpea-vine hay.....	90	2	798	21.86	1.95	3.27
4.55 pounds cotton-seed meal, 14.79 pounds cotton-seed hulls, 10.44 pounds cowpea-vine hay.....	90	2	831	29.78	2.45	4.68

a Maryland Sta. Bul. 22. b Alabama Canebrake Sta. Bul. 8. c Arkansas Sta. Rpt. 1890, p. 134.

II.—Results of feeding cotton products.

Ration.	Duration of period.	Number of animals.	Average weight of animals.	Digestible organic matter in daily ration.	Nutritive ratio of ration.	Average daily gain in live weight.	Digestible organic matter eaten per pound of gain.	Cost of food per pound of gain.
MISSOURI STATION EXPERIMENTS. (a)								
2-year-old Shorthorn steers.								
1.36 pounds cotton-seed meal, 2.66 pounds wheat bran, 2.32 pounds hay, 53.2 pounds silage, 0.09 pound straw.....	Days. 49	3	Pounds. 991	Pounds.		Pounds. 1.49	Pounds.	Cents.
1.36 pounds cotton-seed meal, 2.66 pounds wheat bran, 4 pounds hay, 2 pounds straw, 12.68 pounds corn fodder.....	49	3	985	.....		1.34	.....	.....
MASSACHUSETTS STATE STATION EXPERIMENTS. (b)								
2-year-old grade Shorthorns.								
3.22 pounds cotton-seed meal, 3.22 pounds wheat bran, 7.49 pounds hay, 7.07 pounds silage, 15 pounds roots, 1.07 pounds barley straw, 4.04 pounds clover and hay, 1.48 pounds barley meal.....	153	2	1,106	.....	1:4.14	1.67	.....	13.60

a Missouri Sta. Bul. 8.

b Massachusetts State Sta. Rpt. 1892, p. 92.

II.—Results of feeding cotton products—Continued.

Ration.	Duration of period.	Number of animals.	Average weight of animals.	Digestible organic matter in daily ration.	Nutritive ratio of	Average daily gain in live weight.	Digestible organic matter eaten per pound of gain.	Cost of food per pound of gain.
MASSACHUSETTS STATE STATION EXPERIMENTS (a)—continued.								
1-year-old grade Shorthorns.								
2.57 pounds cotton-seed meal, 2.86 pounds wheat bran, 6.06 pounds hay, 4.74 pounds silage, 5.71 pounds roots, 0.64 pound barley straw, 3.19 pounds mixed fodder	Days. 188	3	Pounds. 747	Pounds.	1: 3.76	Pounds. 1.22	Pounds.	Cents 12.67
MAINE STATION EXPERIMENTS. (b)								
1 and 2 year old steers.								
1.75 pounds cotton-seed meal, 1.75 pounds corn meal, 14 pounds oat straw	132	2	835	8.61	1: 8.44	.90	9.57	9.70
3.5 pounds corn meal, 14 pounds hay	132	2	808	8.95	1:11.82	1.08	8.28	12.60
VIRGINIA STATION EXPERIMENTS. (c)								
3½-year-old steers.								
6 pounds cotton-seed meal, 6 pounds wheat bran, 10.26 pounds hay	35	2	1,172	.....	1: 3.45	.63	.....	27.20
6 pounds cotton-seed meal, 6 pounds corn meal, 9.07 pounds hay	35	2	1,273	.....	1: 3.65	.86	.....	19.20
4 pounds cotton-seed meal, 6 pounds corn meal, 15 pounds roots	35	2	1,277	.....	1: 4.30	.90	.....	19.20
6 pounds cotton-seed meal, 6 pounds wheat bran, 7.43 pounds hay, 10 pounds silage	28	2	1,327	.....	1: 3.85	.86	.....	18.80
12 pounds corn meal, 6.21 pounds hay, 10 pounds silage	28	2	1,233	.....	1: 9.10	1.82	.....	9.20
6 pounds corn meal, 6 pounds wheat bran, 9 pounds hay	35	2	1,253	.....	1: 7	.80	.....	22.40
PENNSYLVANIA STATION EXPERIMENTS. (d)								
2-year-old steers.								
3 pounds cotton-seed meal, 7 pounds corn meal, 4.36 pounds hay, 1.20 pounds corn fodder	77	2	771	10.20	1: 5	2.11	4.83	7.80
12 pounds corn meal, 4.36 pounds hay, 1.12 pounds corn fodder	77	2	782	11.89	1: 9.90	1.85	6.42	10.10
3-year-old steers.								
4.50 pounds cotton-seed meal, 10.50 pounds corn meal, 6.48 pounds hay, 1.52 pounds corn fodder	77	2	1,256	15.10	1: 5.10	1.88	8.03	12.90
17 pounds corn meal, 6.48 pounds hay, 1.58 pounds corn fodder	77	2	1,270	17.05	1:10	1.85	9.21	14.50
4-year-old steers.								
18 pounds corn meal, 7.27 pounds hay, 1.65 pounds corn fodder	77	2	1,384	18.30	1: 9.30	2.10	8.71	13.80
4.80 pounds cotton-seed meal, 11.19 pounds corn meal, 7.27 pounds hay, 1.72 pounds corn fodder	77	2	1,335	16.76	1: 5.30	1.14	14.70	23.30
2 and 3 year old grade Shorthorn steers.								
First period:								
2.90 pounds cotton-seed meal, 6.09 pounds corn meal, 6.60 pounds corn fodder	19½	4	925	.....	1: 5.80	.96	.....	12.07
11.73 pounds corn meal, 5.11 pounds corn fodder	19½	4	883	.....	1:13.50	1.06	.....	11.12

a Massachusetts State Sta. Rpt. 1892, p. 92.
b Maine Sta. Rpt. 1886, p. 73.

c Virginia Sta. Bul. 3.
d Pennsylvania Sta. Bul. 10; Rpt. 1886, p. 228.

II.—Results of feeding cotton products—Continued.

Ration.	Duration of period.	Number of animals.	Average weight of animals.	Digestible organic matter in daily ration.	Nutritive ratio of ration.	Average daily gain in live weight.	Digestible organic matter eaten per pound of gain.	Cost of food per pound of gain.
PENNSYLVANIA STATION EXPERIMENTS (a)—continued.								
2 and 3 year old grade Shorthorn steers—Continued.								
Second period:								
2.63 pounds cotton-seed meal,								
5.27 pounds corn meal, 8.86	Days.		Pounds.	Pounds.		Pounds.	Pounds.	Cents.
pounds hay.....	31½	4	979	.....	1: 6.30	1.23	.....	10.53
10.46 pounds corn meal, 7.97								
pounds hay.....	29½	4	932	.....	1:10.80	1.24	.....	11.51
MAINE STATION EXPERIMENTS. (b)								
5 to 8 months old Hereford, Shorthorn, and Holstein steers (1 of each in each experiment).								
1.16 pounds cotton-seed meal, 1.16								
pounds wheat bran, 9.65 pounds								
hay, 8.02 pounds silage, 1.16 pounds	233	3	585	7.70	1: 6.70	1.65	4.66	.....
ground oats.....								
1.16 pounds corn meal, 1.16 pounds								
wheat bran, 9.63 pounds hay, 7.85	233	3	582	7.73	1:10	1.64	4.70	.....
pounds silage, 1.16 pounds ground								
oats.....								
18-month-old steers.								
3.50 pounds corn meal, 12 pounds hay.	69	2	742	8.04	1:13.10	.61	13.18	16.55
1.50 pounds cotton-seed meal, 2								
pounds corn meal, 12 pounds hay..	69	2	803	7.90	1: 7	1.15	6.87	8.98
3.50 pounds corn meal, 12 pounds hay.	69	2	908	8.04	1:13.10	.11	73.10	9.38
2 pounds cotton-seed meal, 5 pounds								
corn meal, 10 pounds hay.....	69	2	836	9.64	1: 6.20	1.80	5.35	7.53
2 pounds cotton-seed meal, 3 pounds								
corn meal, 12 pounds oat straw.....	69	2	781	8.18	1: 6.80	1.08	7.57	7.41

a Pennsylvania Sta. Bul. 10; Rpt. 1886, p. 228.

b Maine Sta. Rpts. 1887, p. 89; 1890, p. 71.

III.—Prices per ton of the feeding stuffs used in the above experiments.

Feeding stuffs.	Stations.					
	Maine.	Massachusetts.	Maryland.	Pennsylvania.	Texas.	Virginia.
Corn.....					a\$14.28	.....
Corn meal.....	{ \$22.50 24.00 }		\$18.50	{ \$27.20 30.00 26.00 18.00 }		\$20.00
Corn fodder.....		\$12.00	2.50	5.00		.....
Cotton seed:						
Raw.....					7.00	.....
Boiled.....					9.00	.....
Roasted.....					10.00	.....
Cotton-seed meal.....	{ 30.00 26.00 }	27.50	29.50		20.00	25.00
Cotton-seed hulls.....					3.00	.....
Oats.....		30.00				
Wheat bran.....		23.50				20.00
Hay.....	{ 14.00 10.00 }	15.00	15.00	{ 10.00 13.00 }	6.00	10.00
Straw.....	6.00	5.00				.....
Corn silage.....		2.75			2.00	2.50
Roots.....		7.00	3.00			5.00

a Forty cents per bushel.

Exclusive cotton-seed hull and meal feeding.—The practice of fattening steers on a diet made up exclusively of cotton-seed hulls and meal commenced about 1883. The business has so grown that it is estimated¹ that 400,000 cattle were probably fattened at and in the vicinity of the oil mills of the South in the season of 1893–94, besides large numbers of sheep. It is also likely that 100,000 to 150,000 milch cows were fed on rations made up quite largely of cotton-seed hulls and cotton-seed meal. The ration for fattening cattle is 3 or 4 pounds of meal at first, which is gradually increased to 6, 8, and even 10 pounds per head per day, and all the hulls they will eat. The proportions vary from 2 to 6 pounds of hulls to 1 of meal. Probably the ration at present most common is 4 pounds of hulls to 1 of meal. The feeding is continued from 90 to 120 days.

Emery,² at the North Carolina Station, fed eight native and grade Short-horn steers, loose and tied up in stalls, on rations of cotton-seed hulls and meal (3 to 5.6 of hulls to 1 of meal) with fair gains and the production of beef of good quality. There was little difference in feeding steers loose and tied up, but natives paid better than grades, and 2-year-olds better than 3-year-olds. Chamberlain,³ at the same station, fed three old steers 6 pounds of cotton-seed meal and 18 to 20 pounds of hulls per head per day in the months of May and June without injury to health. In cold weather the same author⁴ fattened four 2-year-old steers on hulls and meal (4 to 1) with good and profitable gains, though the digestion of the animals appeared to be somewhat impaired after 84 days' feeding. He calculated this ration, 4 of hulls to 1 of meal, to have a nutritive ratio of 1:5.12, while actual digestion⁵ of the ration gives 1:7.55.

A 3-year-old steer and a heifer⁶ gained an average of 2.09 pounds per day in 81 days' feeding at the North Carolina Station on a ration of 4.3 pounds of hulls to 1 of meal; and 2 steers⁶ gained 2.24 pounds per head daily on 3.3 pounds of hulls to 1 of meal during 41 days' feeding in cold weather. The cost of food per pound of gain was 4.06 and 4.50 cents, respectively. A single steer⁷ made a gain of 2.39 pounds per day in 59 days' feeding on a ration of 2.2 pounds of hulls to 1 of meal in hot weather without injury to health and at a cost of 3.71 cents per pound for food. This latter ration had a nutritive ratio of 1:4.07. The heaviest feeding of cotton-seed hulls and meal anywhere reported has been done at the North Carolina Station,⁸ where two mature steers averaging 1,065 pounds live weight were fed an average of 16.4 pounds

¹ D. A. Tompkins in *Manufacturers' Record*, 1894, p. 257.

² North Carolina Sta. Bul. 93.

³ North Carolina Sta. Rpt. 1889, p. 117.

⁴ North Carolina Sta. Bul. 81.

⁵ North Carolina Sta. Bul. 87*d*.

⁶ North Carolina Sta. Bul. 81, p. 11.

⁷ North Carolina Sta. Bul. 81, p. 21.

⁸ North Carolina Sta. Bul. 111.

of cotton-seed hulls and 8.7 pounds of meal per day for 96 days (practically 2 of hulls to 1 of meal, with a nutritive ratio of 1:3.72); and two 2½ to 3½ year old steers weighing 1,000 pounds ate an average of 13.5 pounds of hulls and 9.1 pounds of meal per day for 142 days (1½ of hulls to 1 of meal, with a nutritive ratio of 1:3.29). These animals were considered fat for the Raleigh market when the feeding commenced, and yet they gained an average of 1.7 pounds per head daily for the entire period on the two rations, ate the rations with relish, remained in good health, and produced beef of excellent quality, as compared with the average of the season. This was not profitable² feeding, though paying gains were made for 40 to 60 days. The feeding was continued beyond this for observation of the effect of the heavy feeding and for other purposes.

The Texas Station¹ fed rations of 3 and 2.6 pounds of hulls to 1 of meal in long periods with better gains than on any other rations. The Alabama Station² fed 4 to 4.6 pounds of hulls to 1 of meal to old (8 to 18 years) and young steers, with good gains in all cases, but the only profitable gains were with young animals.

At the Arkansas Station³ a ration of 3.3 pounds of hulls to 1 of meal produced faster and cheaper gains than any other combinations of feeding stuffs, and beef of as good quality.

The data relating to the foregoing experiments with exclusive feeding of cotton-seed meal and hulls are shown in the following table, the digestible matter⁴ in the rations being calculated by using the coefficients for rations of hulls and meal nearest to their proportions:

Exclusive cotton-seed hull and cotton-seed meal feeding for beef production.

Ration.	Duration of period.	Number of animals.	Average weight of animals.	Digestible organic matter in daily ration.	Nutritive ratio of ration.	Average daily gain in live weight.	Digestible organic matter eaten per pound of gain.	Cost of food per pound of gain.
NORTH CAROLINA STATION EXPERIMENTS.								
<i>2 and 3 year old native and grade Shorthorn steers. (a)</i>								
Fed loose in stalls on 17.97 pounds cotton-seed hulls, 4.23 pounds cotton-seed meal	Days. 100	4	Pounds. 896	Pounds. 9.86	1:8.34	Pounds. 1.85	Pounds. 5.33	Cents. b3.48
Fed tied up 18.05 pounds cotton-seed hulls, 4.14 pounds cotton-seed meal	100	4	896	9.63	1:8.47	1.73	5.56	b4.03
<i>Grade steers used in No. 1.</i>								
19.73 pounds cotton-seed hulls, 4.34 pounds cotton-seed meal	100	4	979	11.24	1:8.41	1.70	6.61	b4.16

^a North Carolina Sta. Bul. 93.

^b Cotton-seed meal valued at \$24 and cotton-seed hulls at \$2.50 per ton.

¹ Texas Sta. Buls. 6 and 10.

² Alabama Canebroke Sta. Buls. 8 and 15.

³ Arkansas Sta. Rpt. 1890, p. 134.

⁴ North Carolina Sta. Buls. 87d, 97, and 118.

Exclusive cotton-seed hull and cotton-seed meal feeding for beef production—Continued.

Ration.	Duration of period.	Number of animals.	Average weight of animals.	Digestible organic matter in daily ration.	Nutritive ratio of ration.	Average daily gain in live weight.	Digestible organic matter eaten per pound of gain.	Cost of food per pound of gain.
NORTH CAROLINA STATION EXPERIMENTS—continued.								
<i>Native steers used in No. 1.</i>								
16.59 pounds cotton-seed hulls, 3.48 pounds cotton-seed meal.....	Days. 100	4	Pounds. 818	Pounds. 9.43	1:8.35	Pounds. 1.93	Pounds. 4.90	Cents. a 3.32
<i>3-year-old steers used in No. 1.</i>								
18.98 pounds cotton-seed hulls, 4.14 pounds cotton-seed meal.....	100	4	942	10.74	1:8.54	1.72	6.24	a 4.25
<i>2-year-old steers used in No. 1.</i>								
17.34 pounds cotton-seed hulls, 3.97 pounds cotton-seed meal.....	100	4	855	9.93	1:8.28	1.91	5.20	a 3.27
<i>2-year-old steers. (b)</i>								
17.94 pounds cotton-seed hulls, 4.56 pounds cotton-seed meal.....	84	4	934	10.74	1:7.55	1.77	6.07	c 4.90
<i>3-year-old steer and heifer.</i>								
17.23 pounds cotton-seed hulls, 5.27 pounds cotton-seed meal.....	81	2	801	11.06	1:5.89	2.09	5.29	a 4.06
<i>Steers in stalls.</i>								
24.88 pounds cotton-seed hulls, 5.85 pounds cotton-seed meal.....	41	2	1,236	14.67	1:7.52	2.24	6.55	a 4.50
<i>Steer in stall.</i>								
13.10 pounds cotton-seed hulls, 6.03 pounds cotton-seed meal.....	59	1	950	9.46	1:4.07	2.39	3.96	a 3.71
<i>Mature steers. (d)</i>								
Fed tied up 16.44 pounds cotton-seed hulls, 8.71 pounds cotton-seed meal.	97	2	1,065	12.40	1:3.72	1.75	7.10	c 7.38
<i>2½ to 3½ year old steers.</i>								
Fed tied up 13.45 pounds cotton-seed hulls, 9.08 pounds cotton-seed meal.	136	2	1,009	11.36	1:3.29	1.71	6.63	c 7.98
TEXAS STATION EXPERIMENTS.								
<i>2 and 3 year old grade Shorthorns. (e)</i>								
Fed in pen 17.38 pounds cotton-seed hulls, 5.93 pounds cotton-seed meal.	90	4	817	-----	-----	2.29	-----	f 3.72
<i>3 and 4 year old Texas steers. (g)</i>								
Fed in pen 16.38 pounds cotton-seed hulls, 6.34 pounds cotton-seed meal.	83	6	842	11.09	1:3.68	2.43	4.56	f 3.63
ALABAMA STATION EXPERIMENTS.								
<i>8-year-old grade Shorthorn. (h)</i>								
35.39 pounds cotton-seed hulls, 7.61 pounds cotton-seed meal.....	105	1	1,485	-----	-----	2.57	-----	i 6.39
<i>18-year-old work oxen. (j)</i>								
20.78 pounds cotton-seed hulls, 4.95 pounds cotton-seed meal.....	84	2	1,150	-----	-----	1.20	-----	i 8.47
<i>2½-year-old grade Holstein steers.</i>								
18.47 pounds cotton-seed hulls, 4.50 pounds cotton-seed meal.....	84	2	751	-----	-----	2.82	-----	i 3.25
ARKANSAS STATION EXPERIMENTS.								
<i>2 to 2½ year old steers. (k)</i>								
19.24 pounds cotton-seed hulls, 5.75 pounds cotton-seed meal.....	90	2	712	-----	-----	2.74	-----	2.40

a Cotton-seed meal valued at \$24 and cotton-seed hulls at \$2.50 per ton.

b North Carolina Sta. Bul. 81.

c Cotton-seed meal valued at \$24 and cotton-seed hulls at \$3.50 per ton.

d North Carolina Sta. Bul. 118.

e Texas Sta. Bul. 10.

f Cotton-seed meal valued at \$20 and cotton-seed hulls at \$3 per ton.

g Texas Sta. Bul. 6.

h Alabama Canebrake Sta. Bul. 8.

i Cotton-seed meal valued at \$20.90 and cotton-seed hulls \$5 per ton.

j Alabama Canebrake Sta. Bul. 15.

k Arkansas Sta. Rpt. 1890, p. 135.

Exclusive cotton-seed meal and corn-silage rations were compared at the North Carolina Station¹ with exclusive feeding of cotton-seed meal and hulls with the result that silage was found to be worth about \$1 per ton as compared with hulls at \$2.50. Other rations² of cotton-seed meal and corn and soja-bean silage produced good gains, but at greater cost than hulls and meal alone. The results of these trials of cotton-seed meal and silage are summarized below:

Exclusive cotton-seed meal and corn-silage feeding for beef production.

Ration.	Dura- tion of period	Num- ber of ani- mals.	Aver- age weight of ani- mals.	Digest- ible organic matter in daily ration.	Nutri- tive ratio of ration.	Aver- age daily gain in live weight.	Digest- ible organic matter eaten per pound of gain.	Cost of food per pound of gain.
<i>2 and 3 year-old grade Shorthorns.</i>								
42.47 pounds corn silage, 5.51 pounds cotton-seed meal (a)	Days 90	4	Pounds. 852	Pounds.		Pounds. 2.54	Pounds.	Cents. 63.83
<i>Steers in stalls.</i>								
56.83 pounds corn silage, 6.09 pounds cotton-seed meal (c)	57	4	1, 143			2.59		5.57
<i>Grade Jersey steers.</i>								
41.25 pounds corn silage, 5.44 pounds cotton-seed meal	32	2		11.36	1: 4.70	2.55	4.46	4 50
39.70 pounds soja-bean silage, 5.50 pounds cotton-seed meal	34½	2		9.98	1: 2.78	1.61	6.20	d 9.02

a Texas Sta. Bul. 10.

b Cotton-seed meal valued at \$20 per ton, corn silage at \$2 per ton.

c North Carolina Sta. Buls. 81 and 93.

d Cotton-seed meal valued at \$24 per ton, corn silage at \$5 per ton, and soja-bean silage at \$4 per ton.

EUROPEAN EXPERIMENTS.

In a series of experiments³ made under the direction of the Halle Station in cooperation with farmers, cotton-seed meal and peanut meal were added to the rations of fattening oxen and sheep to increase their richness in protein beyond the normal (Wolff) ration. The animals fed the rations richer in protein produced, as a rule, faster and cheaper gains than the ones eating the rations poorer in protein. Märcker and Morgen⁴ fed 15 young steers, averaging 1,100 pounds in live weight, in three lots, for 96 days on a basal ration of 5.5 pounds of hay, 3.74 pounds of chaff and straw, 2.2 pounds of wheat bran, 44 pounds of beet diffusion residue, and 101.2 pounds of potato residue per head daily, to which 1.6, 2.99, and 4.38 pounds of cotton-seed meal and 4.29, 3.41, and 2.42 pounds of maize were added, respectively. The nutritive ratios of these rations were 1:4.1, 1:3.6, and 1:3.1. The average daily gains were 2.64, 2.81, and 2.86 pounds. The gains were slightly in favor of the narrow ratios, and the financial results were decidedly

¹North Carolina Sta. Bul. 81, p. 21.

²North Carolina Sta. Bul. 93, p. 41.

³Märcker and Morgen, Deut. landw. Presse, 1893 (E. S. R., 5, p. 241).

⁴E. S. R., 3, p. 572.

so on account of the increased value of the manure. Böckenförde¹ compared American cotton-seed meal with Erling's fiber-free meal in different quantities in the rations of 16 fattening steers during two years. He concluded that the animals did better on the fiber-free meal.

EFFECT OF COTTON-SEED PRODUCTS ON BEEF FATS.

Harrington and Adriance² found the kidney, caul, and body fats, respectively, of steers fed on cotton-seed meal or on raw, roasted, and boiled seed to have melting points of 4.1°, 3.2°, and 8.7° C. higher than the corresponding fats of corn-fed steers. The fats of steers fed on cotton-seed products gave decided reactions with silver nitrate, and the iodine numbers were somewhat lower, as a rule, than those of the corn-fed ones. Bennett and Menke³ found that a ration of cotton-seed hulls and meal, with or without raw cotton seed, and cowpea-vine hay produced fats with melting points from 2° to 4° C. higher than a ration of corn meal and cowpea-vine hay.

FEEDING COTTON-SEED PRODUCTS TO SHEEP.

ENGLISH EXPERIMENTS.

Experiments⁴ were made at Woburn, England, with sheep at pasture upon 4 acres divided into four 1-acre lots. The sheep in two of the lots received no additional food, and the average gain made was taken as that due to pasturage alone. The sheep in the other two lots received additional foods, as shown in the table below, and the increase in live weight on each of these over that on pasturage alone is considered as gain due to the additional food. This assumes that the pasturage on the different acres was uniform, which is an element of uncertainty. The results are summarized by years in the following table (page 410).

¹Landw. Ann. meckl. pat. Ver., 40 (1884), p. 317; abs. in Jahresber. Agr. Chem., 8, p. 557.

²Texas Sta. Bul. 29.

³Arkansas Sta. Rpt. 1890, p. 142.

⁴Jour. Royal Agr. Soc. England, 2d ser., vols. 14-20, 25, pp. 243, 344, 143, 132, 314, 230, 352, 353.

Woburn experiments with sheep at pasture with and without additional foods.

Pasture.	Number of animals.	Total period.	Total additional foods.		Total gain in live weight.	Increased gain attributed to food in addition to pasture.	Amount of decorticated cotton-seed cake for 1 pound additional gain.	Amount of maize meal for 1 pound additional gain.
			Decorticated cake.	Maize meal.				
1877.		<i>Days.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Clover and rye grass	10	105	728		303	91.25	7.98	
Do.	10	105		728	275	63.25		11.51
Average of 2 lots of 10 each.	10	98			211.75			
1878.								
Clover and rye grass	10	119	672		447	93.50	7.19	
Do.	5	9						
Do.	10	119		728	443.50	90		8.09
Average of 2 lots of 10 and 5 each.	5	9			353.50			
1879.								
Clover and rye grass	10	110	672		328	46.25	14.53	
Do.	10	117		728	435	153.25		4.74
Average of 2 lots of 10 each.	10	104			281.75			
1880.								
Clover and rye grass	10	141	672		261.75	-4.75		
Do.	5	18						
Do.	10	141		728	316.25	49.75		14.62
Average of 2 lots of 10 and 5 each.	5	18			266.50			
1881.								
Dutch clover (a)	10	83	672		433.75	283	2.37	
Do.	10	83		728	351.25	200.50		3.63
Average of 2 lots of 10 each.	10	79			150.60			
1882.								
Dutch clover (a)	10	88	672		344.50	187.75	3.58	
Do.	5	22						
Do.	10	88		728	401.75	245		2.98
Average of 2 lots of 10 and 6 each.	6	22			156.75			
1883.								
Dutch clover (a)	10	98	672		266.25	124.50	5.40	
Do.	10	110		728	210.75	69		10.55
Average of 2 lots of 10 each.	10	110			141.75			
1884.								
Dutch clover (a)	10	94	672		517	88.75	7.57	
Do.	10	95		728	416.50	11.75		
Average of 2 lots of 10 each.	10	88			428.25			
Average							66.95	68.02

a White clover (*Trifolium repens*).

b Not including experiments of 1880 and 1883 on cotton-seed cake and maize meal, respectively.

There is no mention of noticeable variation during the first and second years—1877 and 1878—but the observation is made “that a highly nitrogenous food like decorticated cotton-seed cake does not agree with stock” in warm weather, and that maize meal appears to be a more suitable food for fattening in summer. In 1879 the clover on plat 3 was better (from a top dressing of nitrate of soda on the previous crop) than that on any of the others, and the low gain of the sheep on cotton-seed

cake was thought to be due to unhealthy condition of the sheep; while in 1880 the clover on plat 4 was by far the strongest and best, and the sheep on it made a larger gain than either those receiving no additional food or cotton-seed cake, and nearly as large as those receiving maize meal. During 1881 and 1882, on Dutch clover pasture, the sheep showed most excellent gains for the additional foods, but the variations in weight for 1883 are ascribed "in great measure to the difference in luxuriance of the clover crops," plats 1 and 2 having been injured by the previous heavy crop of barley, with which the clover was sown. The sheep having maize meal for additional food in 1884 did not show as much gain as sheep on pasturage alone, but no mention is made of difference in quality of the pastures.

Experiments¹ covering the winters of 1885-86 and 1886-87 were made to compare the effect of cereals and cotton seed and linseed cakes when fed as additional food to sheep feeding off turnips on the land. In both years the sheep were 10-month-old Hampshire-Oxfordshire Downs. The first trial lasted 106 days and the second 95 days. The first winter the basal ration was 0.328 pound of hay chaff and 20 pounds of ruta-bagas, and the second winter 0.5 pound of hay chaff and 26.4 to 28.8 pounds of ruta-bagas per head. Each lot received a different additional food. The sheep were fed in pens, each lot in a pen by itself. The results were as follows:

Comparative value of cereals and cotton-seed and linseed cakes as additional food for sheep.

Ration.	Num- ber of sheep in lot.	Average live weight of sheep	Digest- ible organic matter in daily ration.	Nutri- tive ratio of ration.	Average daily gain in weight.	Digest- ible organic matter eaten per pound of gain.	Cost of addi- tional food (a) per pound of gain.
Experiments, 1885-86:		<i>Pounds.</i>	<i>Pounds.</i>		<i>Pound.</i>	<i>Pounds.</i>	<i>Cents.</i>
Lot 1, 0.672 pound linseed cake	8	140	2.41	1: 6.78	0.48	5.02	2.81
Lot 2, 0.336 pound linseed cake and 0.336 pound undecorticated cotton- seed cake	8	135	2.34	1: 6.99	.39	5.93	2.79
Lot 3, 0.672 pound wheat or wheat meal.	6	140	2.45	1: 9.20	.49	4.97	2.02
Lot 4, 0.336 pound crushed oats and 0.336 pound barley meal	7	133	2.39	1:10.04	.39	6.12	2.81
Lot 5, 0.336 pound crushed oats and 0.336 pound split beans	6	130	2.42	1: 7.74	.39	6.26	3.35
Experiments, 1886-87:							
Lot 1, 0.687 pound linseed cake	8	173	3.38	1: 8.13	.35	9.67	3.72
Lot 2, 0.687 pound wheat or wheat meal.	8	171	3.33	1:11.90	.33	10.24	3.23
Lot 3, 0.687 pound decorticated cotton- seed cake	8	175	3.31	1: 6	40	8.29	2.69
Lot 4, 0.343 pound linseed cake and 0.344 pound barley meal	8	168	3.18	1: 9.69	.27	11.83	3.96
Lot 5, 0.344 pound barley meal and 0.343 pound decorticated cotton-seed cake.	8	168	3.18	1: 8.05	.20	15.89	4.73

a Aside from hay and roots.

The winter of 1885-86 was an unusually severe one, and sheep died in all the pens except where oil cake was fed. The deaths were not thought to be due to the additional foods, although wheat was not generally considered a safe food for sheep. The lot on wheat made the

¹Jour. Roy. Agl. Soc. England, 2d ser., vols. 22 and 23, pp. 514, 417.

cheapest and best gain. The lots on linseed cake, linseed cake and undecorticated cotton-seed cake mixed, and oats and barley were equal in point of cost, but of the three lots the one on linseed cake gave the largest increase, the gains of the other two lots being practically the same as the lot on oats and beans. During the season of 1886-87 the lot on decorticated cotton-seed cake made the best gain at the lowest cost, those on linseed cake and wheat being second and third in point of increase and third and second in cost of increase, respectively. The cost of increase would of course change with the market values of the foods and when their manurial values are considered the difference in favor of the oil cakes increases. Considering the manurial values of the foods, the estimated cost of additional foods for 1 pound of gain during 1886 was: On decorticated cotton-seed cake, 0.59 cent; on linseed cake, 2.06 cents, and on wheat, 2.38 cents.

AMERICAN EXPERIMENTS.

Three trials in as many years were made at the New York Cornell Station in fattening 42 lambs on carbonaceous rations, made up largely of corn or corn meal, as compared with more nitrogenous rations containing cotton-seed meal with wheat bran or linseed meal, or both.¹ During one year there was no apparent difference in results due to the rations, but in the other two years the lambs fed the more nitrogenous rations made markedly larger gains at less cost and on less digestible food per pound of gain than those fed on the carbonaceous rations. The meat made on the nitrogenous rations contained a greater proportion of lean and was more palatable than that from the carbonaceous rations. The corn meal or carbonaceous rations produced weaker bones and from 46 to 72 per cent less wool than the nitrogenous rations. Another experiment² at the New York Cornell Station with lambs has but little interest here beyond showing the amount of cotton-seed meal in the ration.

Craig³ found a grain mixture of 1 part of linseed meal and 2 parts of corn meal to give slightly better results with lambs at pasture than a like amount of cotton-seed meal and corn meal. Lindsey⁴ fed sheep on rations having nutritive ratios of 1:4.5 and 1:5.5, in which cotton-seed meal was a part of the grain ration, and obtained good and economical gains, and concluded that the "constitutional tendency of the animal," rather than the ration, "governed the amount of fat and flesh produced." Four lambs and four sheep were fed at the New York State Station⁵ in four lots of two each on hay and a grain ration of whole corn in one case and a mixture of equal bulks of wheat bran and cotton-seed meal in the other, practically the same amounts of hay and grain

¹ New York Cornell Sta. Buls. 2, 8, and 47.

² New York Cornell Sta. Bul. 8.

³ Wisconsin Sta. Bul. 32.

⁴ Massachusetts State Sta. Rpt. 1893, p. 83.

⁵ New York State Sta. Rpt. 1888, p. 300.

being eaten in each case. The sheep eating the cotton-seed meal ration died after 6 weeks' feeding. The lambs made the same gains in 132 days on the two rations. The proportion of lean meat in the carcasses of the lambs was 58.3 per cent for those fed cotton-seed meal and 33.1 per cent for those fed whole corn.

Harrington and Adriance¹ found the mutton suet from sheep fed cotton-seed meal to have an average melting point 4° C. and an iodine number 7.8 higher than that from sheep fed corn meal. Whole raw cotton seed is fed to a considerable extent to sheep in the Southern States.

The principal data obtained in the experiments with sheep at the New York Cornell and Massachusetts State stations are summarized in the following table:

Feeding cotton-seed meal in combination with other foods to sheep.

Ration.	Duration of period.	Number of animals.	Average live weight.	Digestible matter in daily ration.	Nutritive ratio of ration.	Average daily gain.	Digestible organic matter per pound of gain.	Cost of food per pound of gain.
NEW YORK CORNELL STATION EXPERIMENTS. (a)								
<i>6-month old Cotswold and South-down lambs.</i>								
0.21 pound cotton seed meal, 0.46 pound linseed meal, 0.291 pound wheat bran, 1.205 pounds hay, 0.45 pound roots	<i>Days.</i> 166	3	<i>Pounds.</i> 61	<i>Pounds.</i> 1.22	1: 3.3	<i>Pound.</i> 0.184	<i>Pounds.</i> 6.62	<i>Cents.</i> b 9.26
0.684 pound corn or corn meal, 0.992 pound hay, 0.45 pound roots	166	3	54	1.03	1: 8.4	.104	9.86	b 13.27
<i>6-month-old Shropshire and South-down lambs.</i>								
0.788 pound corn or corn meal, 0.754 pound hay, 0.735 pound roots	151	2	60	1.08	1:10.9	.161	6.69	c 7.59
0.351 pound cotton-seed meal, 0.771 pound wheat bran, 1.033 pounds hay, 0.662 pound roots	151	2	67	1.21	1: 4.2	.256	4.71	c 6.03
0.205 pound cotton-seed meal, 0.675 pound corn or corn meal, 0.205 pound wheat bran, 0.844 pound hay, 0.801 pound roots	151	2	70	1.27	1: 6.5	.248	5.12	c 6.36
0.205 pound cotton-seed meal, 0.689 pound corn or corn meal, 0.205 pound wheat bran, 0.775 pound hay	151	2	69	1.16	1: 6.3	.191	6.09	c 7.82
MASSACHUSETTS STATE STATION EXPERIMENTS. (d)								
<i>Two lots grade Southdown wethers.</i>								
0.166 pound cotton-seed meal, 0.894 pound silage, 0.812 pound Buffalo gluten meal, 1.148 pounds rowen	88	3	72	1.59	1: 4.5	.274	5.79	e 7.53
0.036 pound cotton-seed meal, 1.381 pounds silage, 0.626 pound Buffalo gluten meal, 1.307 pounds rowen	88	3	77.8	1.474	1: 5.5	.254	5.80	e 7.42

a New York Cornell Sta. Buls. 2 and 8.

b Cost per ton of foods: Cotton-seed meal, \$23; linseed meal \$26; corn meal, \$26; wheat bran, \$18; hay, \$10.

c Cotton-seed meal, \$22.50; corn meal, \$20; wheat bran, \$18; hay, \$7.75; roots, 5 cents per bushel.

d Massachusetts State Sta. Rpt. 1893, p. 83.

e Cotton-seed meal, \$28; silage, \$2.75; Buffalo gluten meal, \$21; rowen, \$15.

EUROPEAN EXPERIMENTS.

Märcker and Morgen¹ fed 60 sheep in 6 lots of 10 each. With a constant basal ration, 3 lots were fed cotton-seed meal and wheat bran in varying proportions, the cotton-seed meal replacing a part of the wheat bran in the case of different lots. The amounts of cotton-seed meal fed to the lots of 10 lambs were 1.43, 3.08, and 4.62 pounds, respectively, and of wheat bran 9.68, 7.48, and 6.27 pounds respectively. The nutritive ratios of the rations were 1:4.3, 1:3.6, and 1:3.2. The average daily gains were 1.67, 1.94, and 2.13 pounds per lot of 10 head. Three other lots of 10 sheep each were fed 2.75, 2.31, and 1.87 pounds of cotton-seed meal, respectively, and 1.10, 3.30, and 5.39 of maize, with the same basal ration. The nutritive ratios were 1:4.2, 1:4.6, and 1:5, and the gains 2.13, 2.02, and 2.55, respectively. The greatest gain in the first series was on the ration having the narrowest nutritive ratio and in the last on the one having the widest. The feeding, though liberal, was at a financial loss. Garola² reports upon experiments made by Vitalis, where 250 grams Egyptian cotton-seed cake and 300 grams hay fed daily to milch ewes produced 40 per cent more milk than 1,000 grams of the same hay alone, and at 60 per cent of the cost. The percentage of raw wool was also greater where the oil cake was fed.

FEEDING COTTON-SEED PRODUCTS FOR PORK PRODUCTION.

Considerable interest was awakened in the South a few years ago as to the feeding of cotton seed to hogs, and cotton seed has, no doubt, been fed to hogs by some farmers with success, especially after allowing it to remain piled in the open air for a time to "kill" the seed and soften the hard seed coat, or to stand in shallow water for a number of days to soften the hulls; but this was merely supplementary to the range and not for rapid fattening. The carefully conducted experiments noted below indicate, as a rule, that cotton products are positively injurious to hogs and can not be safely used, at least not in any quantity.

In two years Curtis³ fed at the Texas Station 35 pigs, 3½ to 11 months old, on rations containing large proportions of cotton-seed meal, or cotton seed either roasted, boiled, or soaked, and on corn alone. The average ration per pig was from 1 to 1.4 pounds of cotton-seed products. The corn-fed pigs all did well, making an average daily gain of 1.3 to 1.6 pounds; but those receiving cotton-seed products could not be induced to eat enough food for rapid growth. They gained from 0.4 to 0.7 pound per day, and were usually taken sick in

¹ Magd. Ztg., 1888, Nos. 597 and 625; abs. in Jahresber. agr. Chem., 12 (1889), p. 611; E. S. R., 3, p. 572.

² Abs. in Jour. Am. Chem. Soc., 15 (1893), p. 659.

³ Texas Sta. Bul. 21.

six to eight weeks after the feeding began. The mortality of the pigs receiving cotton-seed meal was 87 per cent, roasted seed 75 per cent, and boiled seed 25 per cent. It was also observed that the pigs escaping sickness and death for thirty days beyond the time when sickness usually set in were safe from attack, but were permanently stunted in growth. Small amounts of cotton-seed meal in the slops are stated to have caused deaths in the college herd of swine in previous years. Curtis concludes "that there is no profit whatever in feeding cotton seed in any form or cotton-seed meal to hogs of any age."

Roberts,¹ at the New York Cornell Station, endeavored to feed a 4-year-old sow 2 pounds of cotton-seed meal along with 4 pounds of wheat bran and 2 pounds of corn per day. She was finally induced to eat one-half pound of cotton-seed meal per day for 143 days, when she was slaughtered and gave evidence of having produced a greater proportion of lean meat than fat. The nutritive ratio of the ration was 1:5.2.

Experiments at the Massachusetts State Station² in 1883 failed to prove that the addition of cotton-seed meal or wheat bran or both to corn meal made a more valuable food for pigs than corn meal alone. One pig in the experiment eating corn meal and wheat bran died of apoplexy. At the Virginia Station³ 3 pigs were fed a ration of 5 parts cotton-seed meal, 2 parts bran, and 2 parts beef scrap, giving a nutritive ratio of 1:2.35. All died within eight weeks after the feeding commenced. The Kentucky Station⁴ concluded that cotton-seed meal could not be fed to hogs profitably for either growth or fattening. E. O. Call⁵ (farmer) fattened 20 hogs on boiled cotton seed, and stated that he had never seen healthier hogs. Harrington and Adriance⁵ examined the lard made from these hogs and found it to have an average melting point of 90° C. higher and an iodine number 2 per cent less than lard from corn-fed hogs. It also reduced silver nitrate to a considerable extent. Wheeler⁶ fed 18 pigs, from 19 to 39 weeks old, on a mixture of 1 part cotton-seed meal, 6 of wheat middlings, 2 of bran, and 4 of corn during 35 days, and a mixture of 1 part cotton-seed meal, 4 of middlings, 2 of bran, and 6 of corn during a second 35 days' period, with fairly good results.

At the North Carolina Station⁷ a mature hog was fed in three periods of 20 days each on $\frac{1}{4}$, $1\frac{1}{4}$, and 2 pounds of cotton-seed meal and 2, $2\frac{1}{2}$, and 3 pounds of wheat bran, respectively, with skim milk and green food. The hog did well until the third period, when it refused to eat so much cotton-seed meal, became sick, and lost weight, but recovered

¹New York Cornell Sta. Bul. 5.

²Massachusetts State Sta. Rpt. 1883, p. 40.

³Virginia Sta. Bul. 10.

⁴Kentucky Sta. Bul. 19.

⁵Texas Sta. Bul. 29.

⁶New York State Sta. Rpt. 1892, p. 286.

⁷North Carolina Sta. Bul. 109.

on the substitution of corn meal for cotton-seed meal in the ration. Another hog, similar to this one and fed the same, except that the cotton-seed meal was replaced by equal amounts of corn meal, remained healthy and gained steadily.

FEEDING COTTON-SEED PRODUCTS TO CALVES.

In an experiment at the Mississippi Station,¹ Irby fed 21 calves, in 7 lots of 3 each, on cotton-seed products in comparison with corn chop, wheat bran, and skim milk, each fed alone. Each lot contained 1 grade Holstein and 2 grade Jersey calves. The trial lasted 56 days. The results were as follows:

Results of feeding cotton seed and cotton-seed meal to calves.

[Mississippi Station.]

Lots.	Average daily ration.	Average live weight at beginning.	Average daily gain in weight.	Organic matter in ration.	Digestible organic matter in ration.	Nutritive ratio.	Cost of food per pound of gain.
		Pounds.	Pounds.	Pounds.	Pounds.		Cents.
1	1.61 pounds cotton-seed meal and 13.19 pounds skim milk	265	1.20	2.55	2.26	1: 1.21	6.8
2	13.34 pounds whole milk	155	1.17	1.61	1.61	1: 4.32	14.16
3	2.96 pounds wheat bran and 12.96 pounds skim milk	216	.74	3.59	2.70	1: 2.17	12.7
4	1.91 pounds corn chop	215	.40	1.58	1.37	1:11.72	3.8
5	25.04 pounds skim milk	215	1.57	2.28	2.28	1: 1.30	7.98
6	4.35 pounds crushed cotton seed	209	.85	3.66	2.45	1: 4.92	2.1
7	5.23 pounds boiled cotton seed	234	.67	2.26	1.30	.....	3.25

Good and profitable gains were obtained on cotton-seed products without injury to the health of the animals, the cheapest gains being on boiled and crushed cotton seed.

At the Pennsylvania Station Hunt² fed 3 calves, 2 months old, 1 pound of cotton-seed meal in 2 pounds of hot water, added to 16 pounds of skim milk per day and per head. Two of the calves died after about 1 month's feeding. Post-mortem examination of one of these showed the lungs and pleuræ to be inflamed. The third calf, as well as 6 others fed similarly except as to cotton-seed meal, kept in good health and made fair gains.

The Arkansas Station³ fed calves weighing 200 to 350 pounds for 9 weeks on cotton-seed hulls and cotton-seed meal (proportion not stated) with good average gains. Two calves, 2 to 3 weeks old, were fed 1 to 6 ounces of cotton-seed meal in 6 to 16 pounds of skim and whole milk per head and day, according to age, at the North Carolina Station.⁴ They died after about 30 and 40 days' feeding, apparently from the toxic effect of the cotton-seed meal, which powerfully affected the nervous system. Leitze⁵ investigated several cases of death of calves

¹ Mississippi Sta. Bul. 8.

² Pennsylvania Sta. Bul. 17.

³ Arkansas Sta. Rpt. 1889, p. 82.

⁴ North Carolina Sta. Bul. 109.

⁵ Milch Ztg., 23 (1894), p. 38.

9 to 12 months old attributed to cotton-seed meal. These calves were fed 3 heaping liters (more than 3 quarts) of cotton-seed meal daily in addition to milk, hay, and linseed cake. Symptoms of disease were noticed about 10 days before death. The autopsy showed hypertrophy of the heart and congestion of the lower lungs, liver, and spleen. Veterinarian Vallers remarks, with reference to the above, that cotton-seed meal causes a yellowing of the animal body.

Emmerling¹ reports on feeding 12 calves, 4 to 6 months old, on cotton-seed meal and milk. Seven died after 3 weeks' feeding. The lungs, intestines, and stomach were inflamed. Another instance is noted where old and young animals ate 1 pound of cotton-seed meal per day without injury.

FEEDING COTTON-SEED PRODUCTS TO HORSES AND MULES.

But little definite information has been found as to the use of cotton products as food for horses and mules. Favorable statements have appeared in the agricultural press from time to time, but little or no data have been presented. Baron E. d'Allinges, agriculturist of the Biltmore estate, Biltmore, N. C., writes that he has fed working horses and mules during 6 days of the week for 3 years on the following ration: Thirteen to 15 pounds of cut hay and corn fodder, 4 pounds of wheat bran, 2 pounds of cotton-seed meal, and 6 pounds of corn meal. On Sundays he gives whole corn and oats and uncut hay.

At the North Carolina Station² 2 old horses were fed for 2 periods of 12 and 18 days on 2 and 2½ pounds of cotton-seed meal, respectively, with 4 pounds each of corn meal and ship stuff and clover and timothy hay. The animals ate the rations well and gained weight.

Gebek³ states that draft horses do well on 2 pounds of cotton-seed meal daily in their rations.

COTTON-SEED PRODUCTS FOR MILK AND BUTTER PRODUCTION.

AMERICAN EXPERIMENTS.

Lloyd⁴ found in 2 years' experiments at the Mississippi Station that raw cotton seed was more economical for milk and butter production as regards quantity than steamed or roasted seed or cotton-seed meal, and that the latter was much cheaper than corn meal. The butter from raw seed, however, was sticky, poor in flavor, and brought less for the outlay than that from cows fed on steamed seed, the butter in the latter case being much superior in quality to any of the rest. A third year's test and a summary of the 3⁵ give steamed seed as a better and cheaper

¹ Centbl. agr. Chem., 1884, p. 472.

² North Carolina Sta. Bul. 109.

³ Landw. Vers. Sta., 42, p. 279.

⁴ Mississippi Sta. Buls. 13 and 15.

⁵ Mississippi Sta. Bul. 21.

milk and butter producing food than either raw seed or meal, butter from the latter costing nearly twice as much as from steamed or raw seed. The data for these experiments are summarized in the following table:

Feeding cotton-seed products for milk and butter production.

Ration.	Duration of period.	Number of animals.	Average daily milk yield.	Fat content of milk.	Cost of food per gallon of milk.	Average daily butter production.	Cost of food per pound of butter.
MISSISSIPPI STATION EXPERIMENTS.							
7 natives, 2 grade Jerseys, and 1 grade Devon. (a)							
8.60 pounds raw cotton seed, 9.38 pounds Bermuda hay.....	Days. 84	10	Gallons. 1.03	Percent.	Cents. 7.8	Pound. 0.466	Cents. 15.70
9.82 pounds raw cotton seed, 8.47 pounds mixed hay.....	84	10	.98	.....	7.5	.441	15.62
9.70 pounds cotton-seed meal, 14.16 pounds Bermuda hay.....	84	10	1.37	.....	11.7	.544	26.83
9.92 pounds cotton-seed meal, 12.09 pounds mixed hay.....	84	10	1.24	.....	11.5	.545	23.62
12.18 pounds Bermuda hay, 9.90 pounds corn meal.....	84	10	1.10	.....	14.3	.386	37.31
9.80 pounds mixed hay, 9.66 pounds corn meal.....	84	10	1.04	.....	12.9	.364	33.65
4 grade Jerseys and 1 grade Holstein. (b)							
9.5 pounds raw cotton seed, 9.2 pounds Bermuda hay.....	35	5	1.10	5.62	7.7	.498	17.4
10.6 pounds roasted cotton seed, 10.5 pounds Bermuda hay.....	35	5	1.22	5.55	8.5	.545	19.1
10.4 pounds boiled cotton seed, 8.5 pounds Bermuda hay.....	35	5	.97	5.64	8.8	.439	19.6
9.9 pounds corn meal, 9.9 pounds Bermuda hay.....	35	5	1.47	3.86	12.8	.455	41.4
9.5 pounds raw cotton seed, 8.5 pounds timothy hay.....	35	5	.91	5.43	12.8	.396	29.5
9.5 pounds raw cotton seed, 10.9 pounds Bermuda hay.....	35	5	1.30	5.38	12.3	.560	28.5
4 grade Jerseys and 1 grade Holstein. (c)							
7.8 pounds raw cotton seed, 7.7 pounds Bermuda hay, 10 pounds silage.....	35	5	1.09	5.95	6.3	.522	13.2
8 pounds raw cotton seed, 4.9 pounds timothy hay, 9.8 pounds silage.....	35	5	.97	5.73	8.3	.438	18.4
9.9 pounds boiled cotton seed, 7.5 pounds Bermuda hay, 9.9 pounds silage.....	35	5	1.56	5.84	4.9	.717	10.9
9.9 pounds boiled cotton seed, 6.5 pounds timothy hay, 9.9 pounds silage.....	35	5	1.30	5.87	8.4	.602	18.1
8.8 pounds cotton-seed meal, 10.2 pounds Bermuda hay, 9.9 pounds silage.....	35	5	1.51	5.74	9.8	.680	22
8.8 pounds cotton-seed meal, 8.8 pounds timothy hay, 9.9 pounds silage.....	35	5	1.51	5.70	12.6	.685	28.1

a Bul. 13.—Cost of foods per ton in these tests: Raw cotton seed, \$9; cotton-seed meal, \$20; Bermuda hay, \$10; mixed hay, \$7; corn meal, \$20.85.

b Bul. 15.—Cost of foods in these 6 experiments per ton: Raw cotton seed, \$6; boiled cotton seed, \$6.30; roasted cotton seed, \$7.20; cotton-seed meal, \$20; Bermuda hay, \$12.50; corn meal, \$25; timothy hay, \$20.80.

c Bul. 21.—Roasted and boiled cotton seed and cotton-seed meal were same prices as in note 2; Bermuda hay, \$10; timothy hay, \$21.46; and silage, \$2 per ton.

Vanderford,¹ at the Tennessee Station, found it more economical to purchase and add cotton-seed meal and wheat bran to home-grown rations than to feed them alone. The same experimenter² did not succeed well in getting cows to eat a ration composed entirely of cotton-seed hulls and cotton-seed meal, and advises the use of 15 pounds of

¹ Tennessee Sta. Bul., Vol. V, No. 3.

² Tennessee Sta. Bul., Vol. VI, No. 2.

hulls and 5 pounds of cotton-seed meal per 1,000 pounds live weight for milk, and the same amount of hulls and 3 pounds meal for butter, with other foods in each case.

As the result of two years' experiments at the Maine Station with 7 cows, Jordan¹ found that "the substitution of cotton-seed meal for an equal quantity of corn meal unmistakably increased the production of milk and butter to a profitable extent," though the total amount of digestible matter in the two rations was practically the same. Curtis² observed during seven years' observations and experiments that cotton-seed meal added to the ration increased the yield of milk and butter, and kept down the proportion of milk to butter. The best results were obtained from a mixture of "ground stuff" and cotton-seed meal, with a nutritive ratio of about 1:4, with pasturage.

Hunt,³ at the Pennsylvania Station, fed 6 pounds of cotton-seed meal per head daily to cows without apparent injury to health and by substituting equal weights of cotton-seed meal for wheat bran increased the milk yield one-fifth without changing the quality of the milk.

Armsby⁴ concludes from experiments with three cows that "increasing the proportion of protein in the ration by substituting cotton-seed meal or malt sprouts for corn meal had no effect upon the milk production."

Four Jersey cows were fed at the New York State Station⁵ for 160 days on coarse foods and a grain ration in one case of corn meal, and of cotton-seed meal in the other. "The feeding of cotton-seed meal was accompanied by an increased hay consumption" and milk yield, which was sufficiently marked to indicate that cotton-seed meal had decidedly affected the milk yield, while corn meal seemed to have had but little specific effect on yield.

When corn meal and cotton-seed meal were fed in like amounts in connection with a basal ration, Whitcher⁶ found a slight difference in favor of the cotton-seed meal for milk production. The grain ration of the New York Cornell Station⁷ dairy herd of 20 cows during the winter months of 1892 was 8 pounds, consisting of 3 parts of wheat bran, 2 of cotton-seed meal, and 6 of corn meal; the summer grain ration was 3 pounds of wheat bran and 1 of cotton-seed meal, the cows being at pasture in summer and eating clover hay, silage, and roots in winter. On these, milk was produced during the entire year for an average of 62.5 cents per 100 pounds and butter for 15.8 cents per pound. The grain ration used by the Maine Station⁸ in a two years' test of dairy

¹Maine Sta. Rpts. 1885-86, p. 65, and 1886-87, p. 84.

²Texas Sta. Bul. 11.

³Pennsylvania Sta. Bul. 17.

⁴Wisconsin Sta. Rpt. 1884, p. 87.

⁵New York State Sta. Rpt. 1886, p. 28.

⁶New Hampshire Sta. Bul. 8.

⁷New York Cornell Sta. Bul. 25.

⁸Maine Sta. Rpts. 1889, p. 106, and 1890, p. 17.

breeds was 6 to 8 pounds, consisting of 2 parts of corn meal and 1 part each of cotton-seed meal and wheat bran. The same station¹ in a 105 days' test of 3 cows obtained an increase of 20 to 36 per cent—an average of about 5 pounds per day—in the yield of milk by substituting 2 pounds each of cotton-seed meal and gluten meal for 4 pounds of corn meal in rations otherwise alike, the milk from the nitrogenous ration being as a rule higher in total solids than that from the corn meal ration.

At the Vermont Station² a farrow cow ate a maximum of 12 pounds equal parts of cotton-seed meal and wheat bran with coarse foods for 16 days and gave slight increase of milk of about the same quality. This cow afterwards died from overfeeding, but not until some time after the grain ration had been changed.

At the Massachusetts Station³ equal weights of cotton-seed meal were compared with gluten meal, linseed meal, and corn meal in different rations. From the results as stated it appears that the yield of milk was somewhat larger when cotton-seed meal was fed than when either gluten meal or linseed meal was used, while with corn meal⁴ there was practically no difference in yield. The net cost of the cotton-seed meal rations was less than any of the others, on account of the increased manurial value of cotton-seed meal over the other meals.

EUROPEAN EXPERIMENTS.

Ritter⁵ fed milch cows 137½ pounds of peanut meal with other foods in a 12-day period, and obtained an average daily milk yield of 484.3 liters (liter = 1.05 quarts). In a second period of 15 days the same cows ate 137½ pounds of cotton-seed meal, with the same basal ration as before, and gave 503.8 liters of milk daily. The cotton-seed meal ration thus produced 19½ liters more milk daily than the peanut-meal ration.

Siewert⁶ found, in a series of experiments, undecorticated Egyptian cotton-seed cake, as a rule, to be of less value for milk production than rape-seed cake, but states that the former has been found better for fattening and safer to feed to young cattle. One and one-fourth pounds of American decorticated cotton cake in ration produced more milk than 2½ pounds of the undecorticated Egyptian cake in the same ration, and as much as 2 pounds of rape cake. Siewert claims that the cotton-seed cakes increased the sugar content of the milk over rape cake and reduced the fat. Preser⁷ fed 5 cows 8.8 pounds of hay, 11 of cut straw, 66 of

¹Maine Sta. Rpt. 1893, p. 73.]

²Vermont Sta. Rpt. 1890, p. 75.

³Massachusetts State Sta. Rpt. 1891, p. 44.

⁴Massachusetts State Sta. Rpt. 1892, p. 28.

⁵Milch Ztg., 1879, p. 561; abs. in Jahresber. agr. Chem., 2, p. 431.

⁶Landw. Vers. Stat., 30 (1884), p. 145; abs. in Jahresber. agr. Chem., 7 (1884), p. 516.

⁷Wien Landw. Ztg., 1880, p. 527; abs. in Jahresber. agr. Chem., 3 (1880), p. 467.

sugar-beet diffusion residue, and 6.6 of cotton-seed meal per head and day, and obtained very large increase in live weight.

Schrodt and von Peter¹ fed cotton-seed meal and peanut meal in rations otherwise alike to 3 cows for milk production, and obtained results favorable to cotton-seed meal. Pogge² compared 2.2 pounds of cotton-seed meal with the same amount of peanut meal in rations otherwise alike. Ten cows in 2 lots were fed each ration for 15 days. More milk and butter was produced on the cotton-seed meal ration than on the peanut-meal ration, the butter from the two rations being equally good. Backhaus³ added 2.2 pounds of peanut cake, 2.2 of cotton-seed cake, and 3.3 of palm-nut cake per head and day to the same basal ration of 10 cows in separate periods of about two weeks each. He concludes that there was no practical difference in the cakes in their effect on either the milk production or fat content of the milk, and further infers that the fat content of milk can be but little changed by the manner of feeding.

The Halle Experiment Station,⁴ in experiments in cooperation with farmers, fed cotton-seed meal to 1,375-pound cows in increasing proportions from 1.78 pounds to 4.69, and barley meal in decreasing amounts from 4.40 to 2.38 pounds, with the same basal ration. The nutritive ratio was thus reduced from 1:4.9 to 1:3.6 without materially affecting the milk yield. The feeding was liberal in amount, and the financial results were slightly better on the narrow ration, on account of its greater manurial value.

EFFECT OF COTTON-SEED PRODUCTS ON THE QUALITY OF BUTTER.

With reference to the effect of cotton seed and cotton-seed meal on the quality of butter, several experiments have been made which showed that the melting point of the butter was higher and the volatile fatty acids lower with cotton seed or cotton-seed meal than without it; i. e., that a firmer, harder butter, which stood handling better, was produced on these foods. This was observed by Curtis and Harrington in several experiments at the Texas Station, the data for which are summarized in the following table:

¹ Milch Ztg., 1881, Nos. 36 and 37; abs. in Jahresber. agr. Chem., 4 (1881), p. 442.

² Landw. Ann. meckl. pat. Ver., 1881, No. 22.

³ Jour. Landw., 41 (1893), No. 4, p. 328 (E. S. R., 5, p. 917).

⁴ Märecker and Morgen, Magd. Ztg., 1888, Nos. 597 and 625; abs. in Jahresber. agr. Chem., 12 (1889), p. 611; and E. S. R., 3, p. 504.

Effect of cotton-seed products on butter.

[Texas Station. (a)]

Ration.	Num-ber of cows.	Days on feed before taking sample of butter.	Examination of butter.			Grading of butter.			
			Melt-ing point of but-ter.	Vola-tile fatty acids of but-ter. (b)	Iodin num-ber.	Flavor 45 points.	Grain 30 points.	Body 25 points.	Total grade 100 points.
Corn and cob meal, oats, bran, silage, sorghum, peavine hay, and pasture	6	8	35.2	28.82	.....	39.25	25.62	22.24	86.51
Cotton seed hulls and cotton seed meal	6	8	40.8	20.30	.....	.....	.....	.....	.....
Raw or cooked whole cotton seed	6	8	40.4	15.70	.....	30.93	18.50	21.25	70.68
1 part cotton-seed meal, 3 parts oats, sorghum, hay, and scant pasture	6	8	37.3	26.28	.....	33.59	21.67	20.54	75.80
Equal parts cooked cotton seed and oats, and scant pasture	6	8	36.6	26.78	.....	34.48	21.87	20.67	76.96
5 pounds millet and peavine hay, 5 pounds bran, 6 pounds corn meal, and good pasture	6	8	.....	.....	.....	38.12	25.44	22.23	85.79
Corn meal, wheat bran, and silage	4	{ 33 16	33.2	26.90	30.22	.....	.....	.....	.....
One-fourth ration cotton-seed meal	4	{ 21 25	36.5	23.72	32.38	.....	.....	.....	.....
One-half ration cotton-seed meal	4	{ 17 14	39.1	20.65	33.04	.....	.....	.....	.....
Three-fourths ration cotton-seed meal	4	{ 14 16	40.6	16.24	35.39	.....	.....	.....	.....
Cotton seed hulls and cotton-seed meal	2	17	41.4	12.15	42.34	.....	.....	.....	.....

a Texas Sta. Rpt. 1889, p. 100; Buls. 11 and 29.

b Calculated for 5 grams of butter.

The authors concluded that cotton seed and its products raised the melting point and lowered the volatile fatty acids of butter very materially, and produced a light-colored butter of inferior quality when fed alone, as a large part of the grain ration, or with scant pasturage, the butter being poor in flavor and presenting the appearance of having been overworked; but when cotton products formed only a moderate part of the grain ration, or were fed with good pasturage, the quality was little affected, the butter being firmer and standing shipment better than that made when no cotton-seed products were fed.

H. W. Wiley¹ examined some of the above butters sent him by Harrington and made experiments in connection with the Maryland Experiment Station, which, together with those of Lupton and Anderson at the Alabama College Station,² confirmed the above results in general.

Wiley found that cotton-seed meal increased the melting point and decreased the iodine absorption and the volatile acids (slightly); and the butter also showed reducing action on silver nitrate. The experiments of Lupton and Anderson indicated that cotton seed and cotton-seed meal usually increased the melting point of butter about 7° C.,

¹Proc. Soc. Prom. Agl. Sci., 1889, p. 84; See also W. Frear in Agl. Sci., 7 (1893), p. 131.

²Alabama College Sta. Bul. 25.

and diminished to a marked degree the volatile acids, but they state that no change was observable in the color of the butter. In experiments by Hunt at the Pennsylvania Station to test the relative effect of cotton-seed meal and wheat bran on the quality of butter, only the melting point and the general quality of the product were determined. The butter made on cotton-seed meal had a considerably lower melting point than that made on bran, and was rated considerably lower by all the judges to whom it was sent. Wood and Parsons, in experiments at the New Hampshire Station,¹ found that cotton-seed meal produced an unusually hard butter, and Morse, in experiments at the same station,² found that cotton-seed meal depressed the volatile acids and iodine number. Cotton seed had slightly more effect on these factors than cotton-seed meal, and cotton-seed oil depressed the volatile acids more than either cotton-seed meal or seed, but the iodine number only slightly.

In experiments by Jordan at the Maine Station in 1891,³ the butter produced on a ration of cotton-seed meal, bran, and corn meal was harder; contained a larger amount of volatile acids, and showed a higher iodine number than that produced on a ration of linseed meal, bran, and corn meal, or of pea and barley meal; but in experiments in 1893, in which a ration of 2 pounds of corn meal, 2 pounds of cotton-seed meal, and 2 pounds of gluten meal was compared with one of 6 pounds of corn meal, there was no difference in the butters shown by chemical tests.

The data for the above experiments, as well as for tests made by Dean and James at the Ontario Agricultural College,⁴ are summarized in the following table:

Effect of cotton-seed products on butter.

Ration.	Num-ber of cows.	Days on feed before taking sample.	Examination of butter.		
			Melting point of butter.	Volatile fatty acids of butter.	Iodin number.
WILEY'S RESULTS. (a)					
Pasturage.....	3	10	° C. 35.4	22.4	38.9
10 pounds cotton-seed meal per day and light pas- turage	3	10	41.9	21.1	34.7
ALABAMA STATION EXPERIMENTS. (b)					
5 pounds oats, 5 pounds corn, 5 pounds bran.....	10	7	35.6	29.8	.....
3 pounds cotton-seed meal, 4 pounds oats, 5 pounds bran, 11 pounds silage	10	7	36.1	30.5	.....
4 pounds cotton-seed meal, 9 pounds cotton-seed hulls, 4½ pounds silage	10	7	37.4	27.5	.....
Raw cotton seed and cotton-seed hulls.....	10	7	43.6	22.1	.....
Cooked cotton seed and cotton-seed hulls.....	10	7	42.7	22.5	.....

a Proc. Soc. Prom. Agl. Sci. 1889, p. 84.

b Alabama College Sta. Bul. 25.

¹ New Hampshire Sta. Bul. 13.

² New Hampshire Sta. Buls. 16, 18, and 20.

³ Maine Sta. Rpt. 1891, p. 62.

⁴ Ontario Agl. College Rpt. 1891, p. 166.

Effect of cotton-seed products on butter—Continued.

Ration.	Num- ber of cows.	Days on feed before taking sample.	Examination of butter.		
			Melting point of butter	Volatile fatty acids of butter.	Iodin number.
NEW HAMPSHIRE STATION EXPERIMENTS. (a)					
40 pounds silage, 5½ pounds hay, 2.05 pounds each of middlings, corn meal, cotton-seed meal, and gluten meal	4		°C.	29.9	38.8
40 pounds silage, 5½ pounds hay, 2.05 pounds mid- dlings, 7.25 pounds cotton-seed meal	4	19		24.9	34
40 pounds silage, 5½ pounds hay, 2.05 pounds mid- dlings, 6.25 pounds raw cotton seed	4	20		20.3	33.8
40 pounds silage, 5½ pounds hay, 2.05 pounds mid- dlings, 3.5 pounds gluten meal, 13.5 ounces cotton- seed oil	1			19.7	37.8
ONTARIO AGRICULTURAL COLLEGE EXPERIMENTS. (b)					
Pasture	2	21	32.3		24.4
30 pounds hay, 9 pounds linseed meal	2	21	33		37
20 pounds hay, 4 pounds linseed meal, 5 pounds cot- ton-seed meal	2	21	34.6		
30 pounds hay, 9 pounds cotton-seed meal	2	21	36.5		35

a New Hampshire Sta. Bul. 16.*b* Ontario Agl. College Rpt. 1891, p. 166.

The figures for the experiments of Harrington and Adriance are the averages of the tests of the two sets of animals on the days when they had been longest on the ration. They show an increase in melting point and iodine absorption, and a decrease in the volatile acids according to the proportion of cotton-seed meal in the ration. These observers state that one-fourth ration of cotton seed or cotton-seed meal does not materially affect the quality of the butter, and that the effect of cotton-seed meal on butter was apparent thirty days after it had been discontinued in the ration, which has an important bearing on all the results above, indicating that few of them, perhaps, were continued long enough to show the maximum effect of the cotton-seed meal on the butter. The results of Dean and James show a marked increase in melting point of the butter where cotton-seed meal was fed. Lloyd¹ states that butter from steamed cotton seed was superior to that from either raw seed or meal, and Brooks² reports that butter produced from cotton-seed meal was hard and of a greasy texture. As the result of two years' experience at the New York State Station³ the butter made from cotton-seed meal was graded first in "firmness," and second in "yield, color, and grain," as compared with butter made from oats, linseed meal, and corn meal in different rations. Mayer⁴ found cotton-seed cake in rations with rye straw and pea straw to produce butter with more volatile fatty acids and lower melting point than peanut, sesame, linseed, or poppy-seed cakes with different coarse foods.

¹ Mississippi Sta. Bul. 21.² Massachusetts Agl. College Catalogue, 1893, p. 30 (E. S. R. 5, p. 969).³ New York State Sta. Rpt. 1889, p. 211.⁴ Landw. Vers. Stat., 41 (1893), p. 15; abs. in Agl. Sci., 7 (1893), p. 126 (E. S. R., 5, p. 509).

EFFECT OF COTTON-SEED PRODUCTS ON CHURNABILITY.

The Texas Station¹ found that as compared with corn-and-cob meal cotton seed and cotton-seed meal facilitated and increased very materially the amount of cream that would rise by gravity at high (70° F.) and low (45° F.) temperatures, but with centrifugal creaming this difference due to foods disappeared. At 70° F. the increase was 8.5 per cent and 14 at 45° F., the results being averages on cows fresh in milk, in medium milk, and well advanced in milk. Cotton seed and cotton-seed meal cream, however, had to be churned at 4° to 8° F. higher temperature if sour, and 1° to 3° F. if sweet, than cream from corn-and-cob meal and other foods. Hunt² observed that milk from cows fed cotton-seed meal creamed better by gravity than that from cows fed bran, and Parsons and Wood³ state that gluten meal decreases the churnability of fat as compared with corn meal or cotton-seed meal. Mayer⁴ found milk from cotton-seed cake rations to be harder to churn than that from peanut, sesame, linseed, or poppy-seed cake rations.

EFFECT OF COTTON-SEED PRODUCTS ON THE HEALTH OF ANIMALS.

Where sickness, death, or other disturbances have occurred with the animals in the previously reported experiments, the fact was there noted. Other observations as to the effect of cotton-seed products on the health of animals are brought together here. Whether cotton products contain originally a toxic principle, or whether such is developed as the result of decomposition outside or of change within the animal body is yet an open question. Emmerling⁵ assumes that the decomposition products of the organisms in cotton-seed residues are responsible for the bad effect of the residues, while the experiments of Brefeld⁶ lead him to believe that such is not the case. Böhm and Maxwell⁷ found cholin, and Ritthausen, Weger, and Maxwell found betaïn in cotton-seed meal (see article on chemistry of cotton, p. 96). Cholin is stated to possess toxic property,⁸ but betaïn is considered a nonpoisonous base. Harrington⁹ examined the blood and viscera of hogs dying from the effects of cotton-seed meal poisoning for ptomaines with negative results. From the variety of symptoms of sickness and post-mortem results, it would appear that there are a number of causes of sickness rather than a single disease. The ill effects of cotton products on hogs are variously credited to the loose lint, the large amount of fat, the

¹ Texas Sta. Buls. 11 and 14.

² Pennsylvania Sta. Bul. 17.

³ New Hampshire Sta. Bul. 13.

⁴ Landw. Vers. Stat., 41 (1893), p. 15.

⁵ Centbl. agr. Chem., 1884, p. 472.

⁶ Jour. Landw., 1887, p. 37; abs. in Landw. Vers. Stat., 42 (1894), p. 305.

⁷ Amer. Chem. Jour., 13 (1891), p. 469.

⁸ Bernthsen, Lehrbuch der organischen Chemie, 1887, p. 183, states otherwise.

⁹ Texas Sta. Bul. 15.

hard and sharp seed coats, etc., while with ruminating animals the blame has fallen on moldy cakes and meal, impurities, hulls, or fiber in them, etc. (See p. 380.)

A review for 1886,¹ published by the Baltic Centralverein, notes that in many instances where sheep and cattle were fed small quantities of cotton-seed meal sickness and death followed, but, strange to say, only male animals were affected. Brüggmann² states that a 1-year-old steer fed cotton-seed meal in water died, while other steers and young cattle given dry cotton-seed meal did well. He therefore warns against feeding moist cotton-seed meal. Klein³ cites a case where a cow died from having eaten cotton-seed cake insufficiently broken up. Nathusius⁴ observed for several years that the uterus of ewes which had been fed considerable quantities of cotton-seed meal immediately after lambing became highly inflamed and the sheep soon died. It is stated that only those animals eating American cotton-seed meal were affected, and when the use of the meal was stopped the trouble disappeared. Relief was found in the use of carbolic acid wash. Gautier⁵ reports sickness in calves and Bongarz⁶ injuries to calves and sheep from feeding cotton-seed meal. Gips⁷ reports the death of 3 out of 8 cattle made sick from eating moldy cotton-seed cake. Esser⁸ reports the death of about 100 fattening lambs after a few days' feeding on 250 gm. cotton-seed meal as auxiliary food. The meal seemed of good quality and was fed to oxen without injury. Schwanefeldt⁹ reports the death of calves from eating cotton-seed meal, and Peschel¹⁰ of cows dying of fever attributed to the effects of cotton-seed cake. Klein¹¹ fed cotton-seed cake to 12 rabbits and to carp. All the animals except one rabbit died in a short time of inflammation of the bowels. Märcker observed in feeding cotton-seed meal to sheep that while ewes would not be affected, male sheep sickened on much smaller rations. Post-mortem examination showed magnesium ammonium phosphate calculi in the bladder, which probably caused irritation and could not be expelled so easily from males as from females.¹² Emery,¹³ of the North

¹Landw. Vereinsschr. balt. Cent. Ver., April, 1887; abs. in Centbl. agr. Chem., 1886, p. 716.

²Hannov. land- und forstw. Ztg., 16 (1885), p. 318; Centbl. agr. Chem., 14 (1885), p. 353.

³Königsberger. land- und forstw. Ztg., 1886; abs. in Jahresber. agr. Chem., 9 (1886), p. 397.

⁴Fühling's landw. Ztg., 35 (1886), p. 114; abs. in Jahresber. agr. Chem., 9 (1886), p. 397.

⁵Dent. Ztschr. für Tiermedizin, 12 (1885-86), p. 377.

⁶Archiv. für wissenschaft. und prakt. Tierheilkunde, 14 (1886), p. 86.

⁷Ibid., 12 (1886), p. 74.

⁸Abs. in Landw. Vers. Stat., 42 (1894), p. 303.

⁹Archiv. für wissenschaft. und prakt. Tierheilkunde, 12 (1886), p. 74.

¹⁰Abs. in Landw. Vers. Stat., 42 (1894), p. 303.

¹¹Centbl. agr. Chem., 1884, p. 772.

¹²Ber. 20te Plenar. deut. Landwirtschaftsrates, Berlin, 1892.

¹³North Carolina Sta. Bul. 109.

Carolina Station, states that 3 milch cows at different times had disturbances of the nervous system from eating cotton-seed meal, and that one died from eating old cotton-seed meal.

Voelcker¹ mentions the death of 5,006 sheep and lambs and serious injury to many others alleged to have been caused by eating decorticated cotton-seed cake. The cake was of good quality, and the sickness and death are ascribed to overeating. He also reports² injury to the health of cattle, and one death, from eating cotton-seed cake of good quality in which no poison could be found, and states that the injury which the cakes undoubtedly did "was clearly traced to the coarse condition and consequent indigestibility of the cotton-seed husks in them." The same authority³ states that "instances in which very moldy feeding cakes have injured or killed cattle are too numerous to leave any room for doubt of the injurious properties of damaged or moldy linseed or other feeding cakes." Instances of death or injury to health of animals resulting from eating moldy cakes, oats, and other foods are numerous and have been ascribed to a mold (*Aspergillus* spp.) known to be poisonous to animals. Zopf found in cotton-seed meal several organisms, particularly *Bacterium vernicosum*, which exercised poisonous powers.⁴

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¹ Jour. Roy. Agl. Soc. England, 8 (1872), pt. 1, p. 219.

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